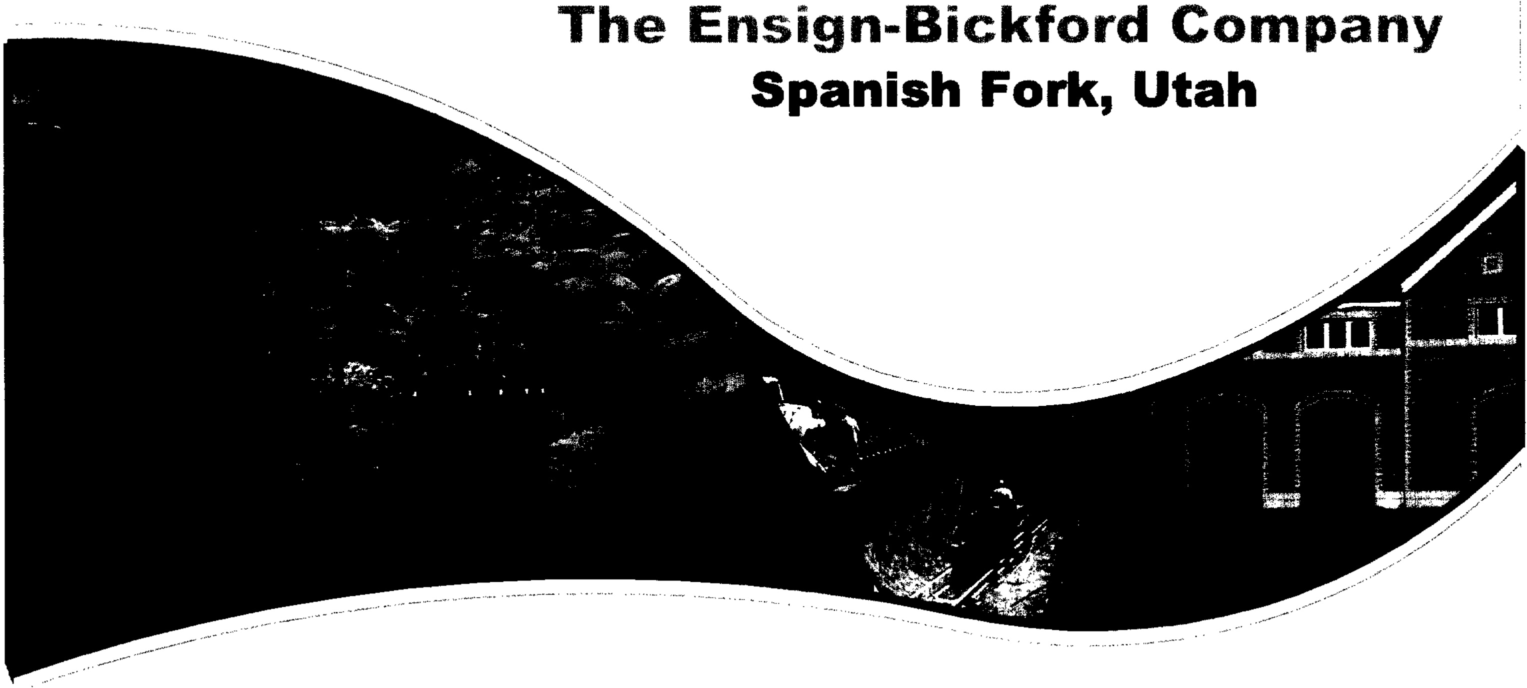
CORRECTIVE ACTION PLAN

The Ensign-Bickford Company
Spanish Fork, Utah



CHARTER OAK

***Revised* May 2002**

6.0 CHARACTERIZATION OF THE STUDY AREA

In accordance with section R317-6-6.15.D.1.b.(1-6) of the Utah Administrative Rules for Ground Water Quality Protection (DWQ, 1995), this section presents a summary of available information and data used to characterize the study area.

6.1 Physical Setting

6.1.1 Geography

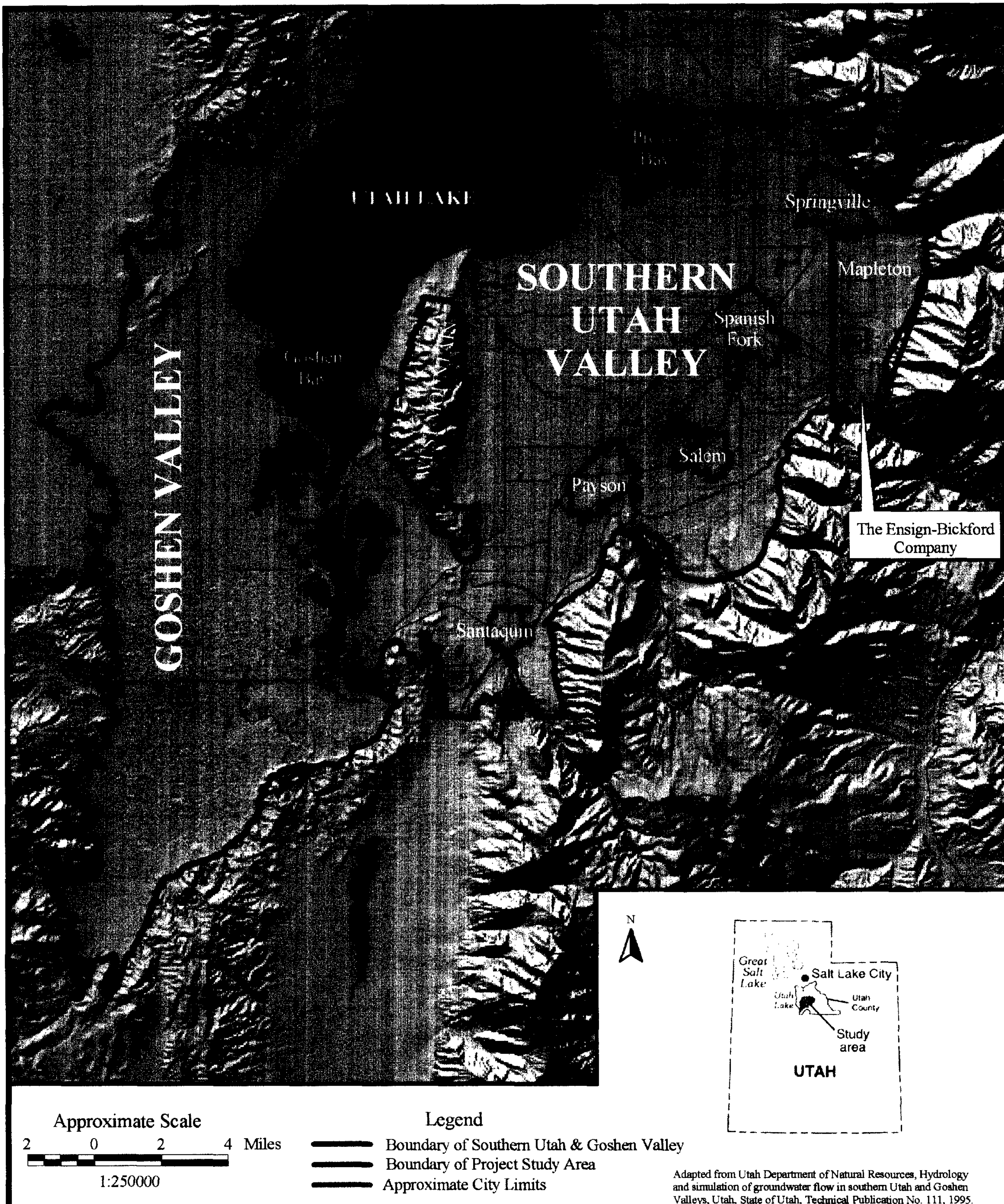
The study area is located in the Great Basin which is a 500,000 km^2 hydrographically defined region of the southwest United States (Mifflin, 1988). The Great Basin covers most of Nevada and Utah as well as portions of Wyoming, Idaho, Oregon and California. The most notable characteristic of the Great Basin is the interior drainage of surface water and ground water. The study area is located at the base of the Wasatch Mountains which form the eastern boundary of the Great Basin in Utah.

The study area is located within an area identified by Richardson (1906) as the Utah Lake Valley. The larger Utah Lake Valley is subdivided into Northern Utah Valley, Southern Utah Valley and Goshen Valley. Figure 6-1, adapted from Brooks and Stolp (1995), shows boundaries of Southern Utah Valley and Goshen Valley. The location of the EBCo property and the outline of the project study area are illustrated. Further discussions in this document will be limited to the area of Southern Utah Valley and the study area.

The EBCo facility is located in the city of Spanish Fork, Utah County, Utah. Figure 6-2 is a site location map showing the site relative to some of the major geographic features in the area including the Wasatch Mountains, major surface streams, Utah Lake, major transportation routes and surrounding communities.

6.1.2 Study Area Topography and Drainage

Land surface altitude in Southern Utah Valley ranges from approximately 4,490 feet at Utah Lake to approximately 5,200 feet along the southeastern margin of Southern Utah Valley. The mountains of the Wasatch Range rise from an elevation of approximately 5,200 feet to altitudes in excess of 10,000 feet east of the study area (Brooks and Stolp, 1995). Cordova (1970) divides the valley floor into two main physiographic units – the lake plain and the highlands. The lake plain extends from the Utah Lake shoreline at an elevation of about 4,490 feet to the western margin of the highlands. The highlands lie between the lake plain and the Wasatch Mountains. Cordova (1970) defined the boundary of the two physiographic units as the 4,600-foot contour line. This is consistent with the area of the East Bench; a topographic feature identified on USGS 7.5 minute topographic quadrangle maps of the area. The East Bench is analogous to the Mapleton



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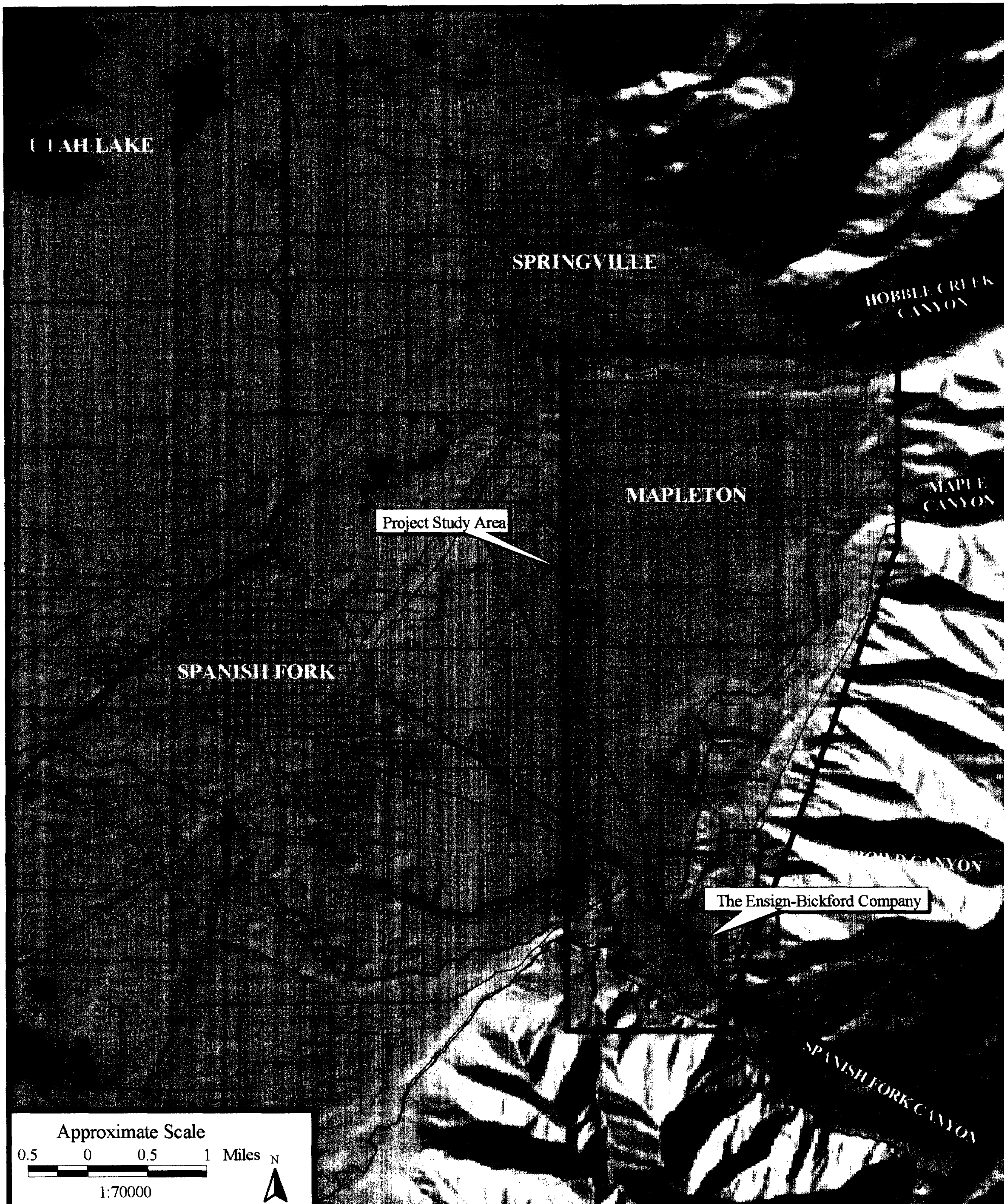
Southern Utah Valley

FIGURE 6-1



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SITE LOCATION MAP

FIGURE 6-2

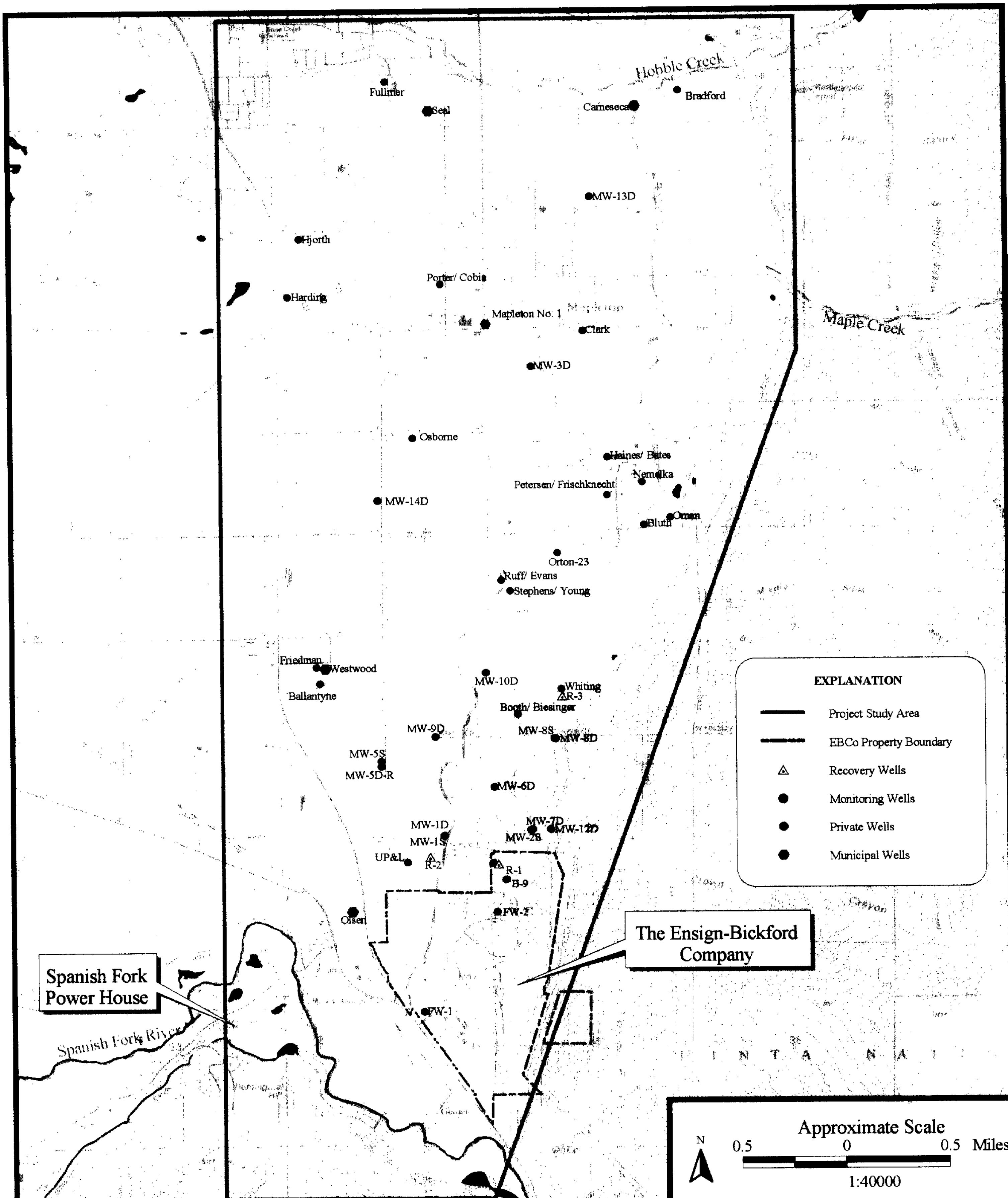
Bench identified by Brooks and Stolp (1995). According to Cordova's characterization of the area, the entire study area falls within the highlands physiographic region.

The topography of the study area is illustrated in Figure 6-3. The easternmost region of the study area consists of the bedrock escarpment of the western slope of the Wasatch Range. The Wasatch Mountains in this area, consisting of Spanish Fork Peak, rise from approximately 5,200 feet to over 10,000 feet over a horizontal distance of approximately one mile. Several steep canyons dissect the west slope of Spanish Fork Peak (Crowd Canyon, Big Slide Canyon, Middle Slide Canyon, Maple Canyon, etc.). With the exception of Maple Canyon, these canyons are ephemeral drainages, drained by underflow in coarse-grained deposits that are located along the axis of the canyons. Free flowing water is rarely observed exiting the canyon mouths and only during times of exceptional spring runoff. This area is referred to in the report as the Wasatch Mountains or the mountain front. A distinctive topographic bench rises steeply from an elevation of approximately 4,820 feet on its western margin to an elevation of approximately 5,200 feet at the mountain front. This topographic feature area is relatively broad at and immediately to the north of the Plant site, thinning northward in the direction of Maple Canyon. This region consists of several flat to rounded hills separated by discontinuous, disjointed ephemeral drainages emanating from the canyon mouths along the mountain front. The engineered Mapleton Lateral flows from south to north along the western margin of this topographic bench at an elevation of approximately 4,820 feet. The western portion of the study area consists of a relatively flat planar surface, sloping gently to the west toward the escarpment defining the edge of the Mapleton Bench and continuing on to Utah Lake.

Two large canyons with significant surface water drainages enter the study area. The southern extent of the study area includes the mouth of Spanish Fork Canyon. Spanish Fork Canyon is a major canyon crossing the Wasatch Mountains. The elevation of the mouth of the canyon is approximately 4,800 feet. The elevation at the crest of the canyon at Soldier Summit, Utah is approximately 7,480 feet. The canyon encompasses a drainage area of approximately 670 square miles (Cordova, 1970). Hobble Creek Canyon, a significantly smaller drainage encompassing approximately 105 square miles, enters the study area from the east at the northern extent of the study area. The natural stream channels of Hobble Creek and the Spanish Fork River empty into Utah Lake.

6.1.3 Climate

According to Hyatt et al. (1969) the climate of Southern Utah Valley is classified as sub-humid. Southern Utah Valley has moderate winters and summers, with a typical frost-free season from May to October (Hyatt et al., 1969). Meteorological data have been collected at the Spanish Fork Power House (Station ID 428119) from 1928 to the present day. The Spanish Fork Power House is located at the mouth of Spanish Fork Canyon approximately one mile west of the Plant site (see Figure 6-3) and meteorological data from this site is probably most representative of the study area.



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Study Area Topography

FIGURE 6-3

The 1928 through 2000 average temperature is 51.9°F (Western Region Climate Center (WRCC), 2002). The highest average monthly temperature occurs in July (76.2°F) and the lowest average monthly temperature is during the month of January (28.6°F).

The average annual precipitation for this same time period is 19.16 inches (WRCC, 2002). Figure 6-4 presents average annual precipitation data for the Spanish Fork Power House from 1928 through 2000. As demonstrated in the Phase IV Hydrogeologic Investigation Report (Owens Western Company, 1995) the quantity of precipitation increases with increasing elevation in the study area. As a result, the Wasatch Mountains receive substantially more precipitation than areas in the valley lowland area. According to the 1999 Utah County Atlas, the valley lowlands area in Southern Utah Valley receives about 10 inches of precipitation per year whereas the Wasatch Mountains to the east will receive between 20 and 50 inches of precipitation annually. The greatest amount of precipitation generally occurs during March and April, with the lowest amount of precipitation occurring during June, July and August. Figure 6-5 presents average monthly precipitation for the Spanish Fork Power House.

Figure 6-4: Average Annual Precipitation Measured at SFPH

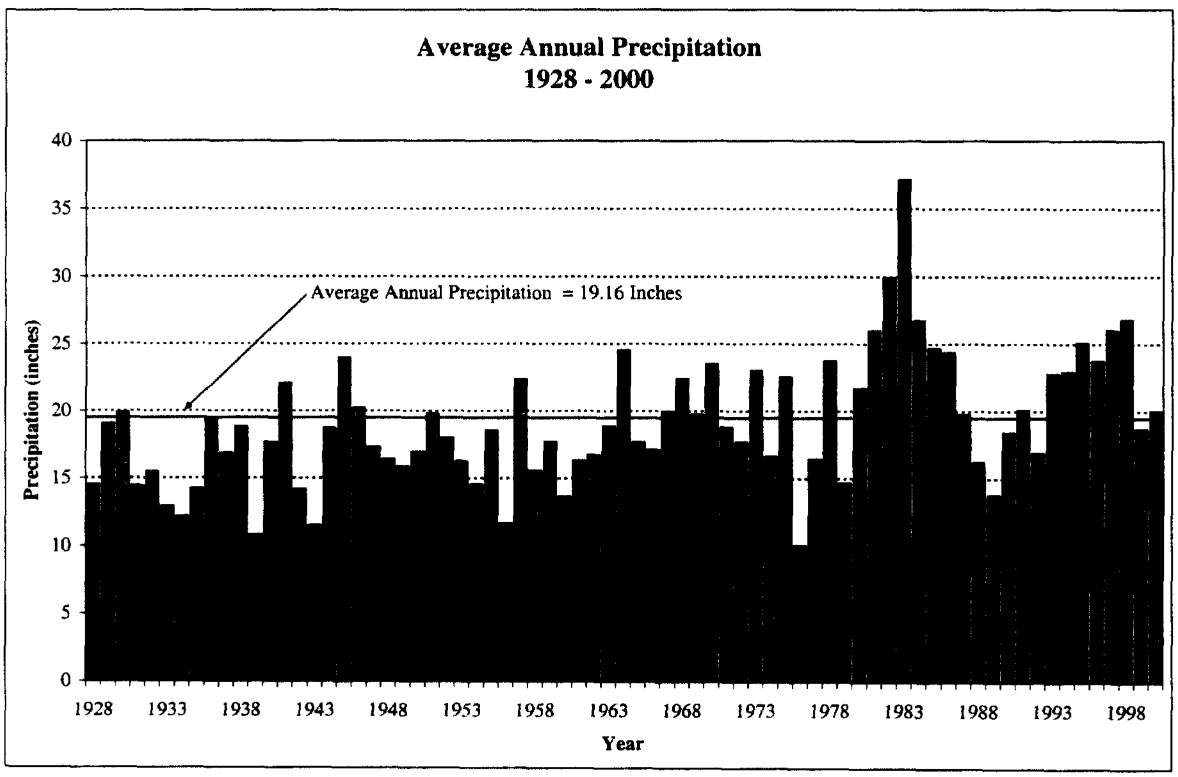
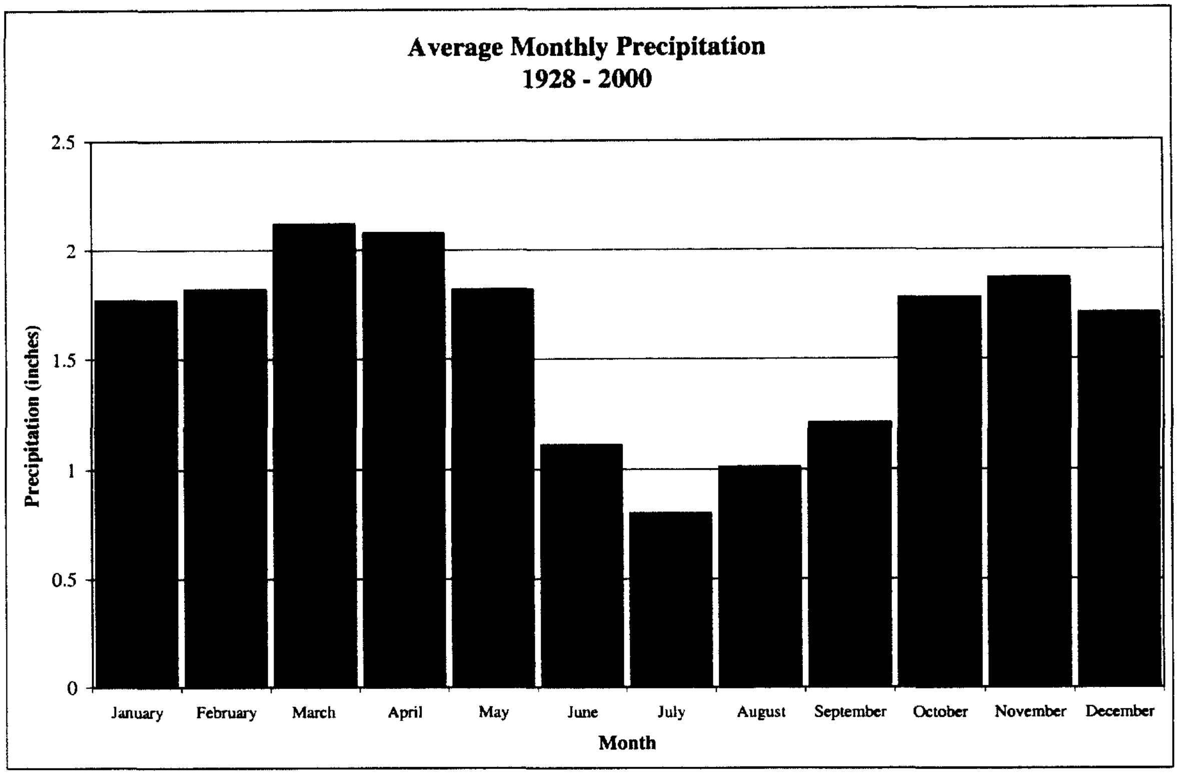


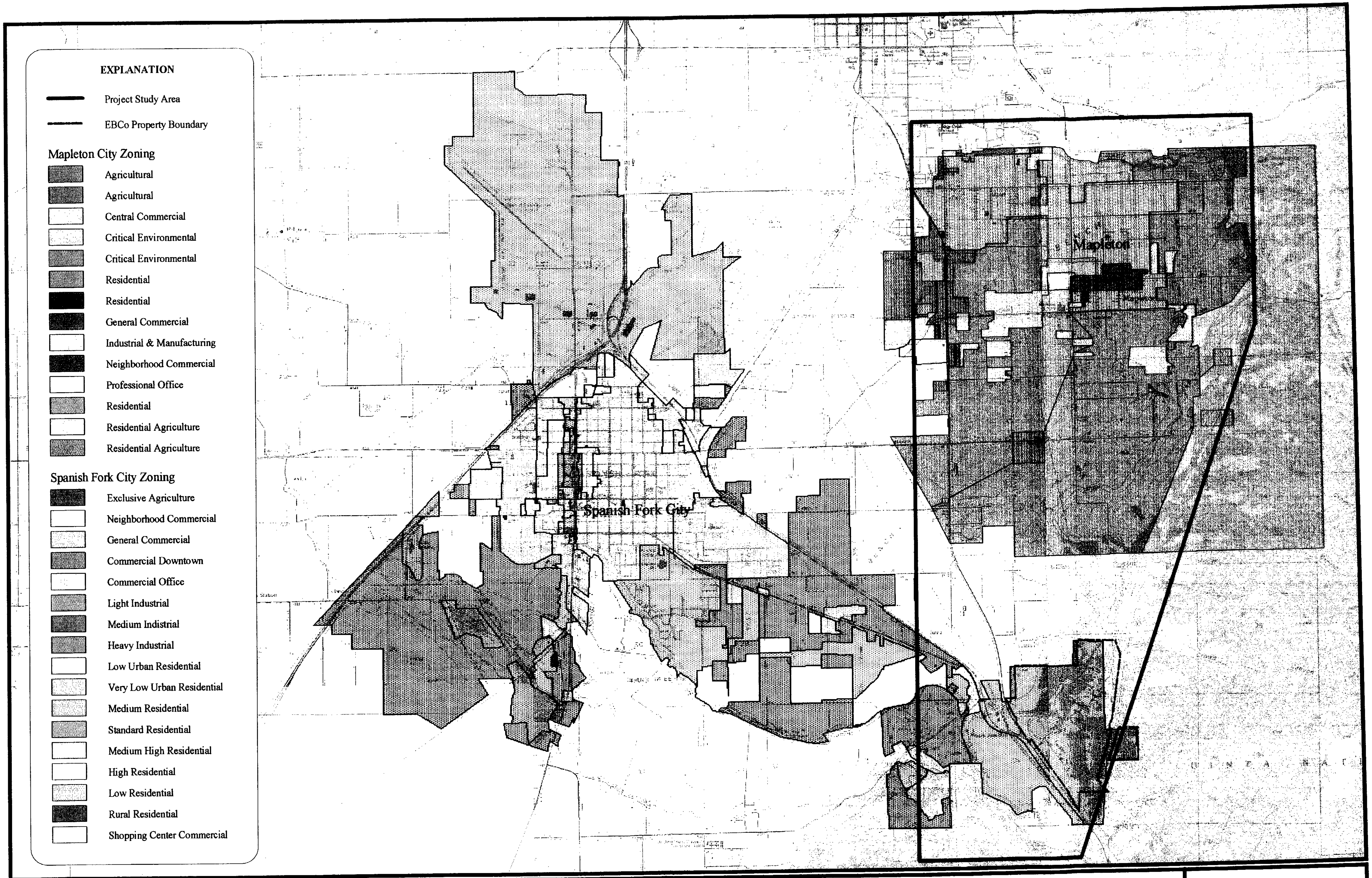
Figure 6-5: Average Monthly Precipitation Measured at the SFPH



6.1.4 Demographics

Spanish Fork, Mapleton and Springville are the three cities that are within or closest to the Spanish Fork study area. The estimated 1997 population of these three cities are 15,444, 4,801 and 16,009, respectively (Utah County Atlas, 1999). The Plant is located within the corporate boundaries of Spanish Fork. Figure 6-6 depicts zoning classifications within the study area. The Plant site and land to the southwest have an industrial land use classification. Residential uses are predominant to the west of the site in Spanish Fork and the north in Mapleton and Springville. Unincorporated lands to the immediate north and northwest of the Plant site and in southern Mapleton are classified primarily as rangeland and are largely of agricultural use. Alfalfa is the predominant crop grown in the study area. Study area land use is illustrated in Figure 6-7.

Generally, agriculture remains the predominant land use in Southern Utah Valley although land use is slowly transitioning from agricultural to residential use (Brooks and Stolp, 1995). Between 1990 and 1997, the populations of Spanish Fork, Springville and Mapleton increased 14.76%, 37.01% and 34.41%, respectively (Utah County Atlas, 1999).



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N

Approximate Scale
0.25 0 0.25 0.5 Miles
1:45000

Spanish Fork City zoning metadata obtained from the Spanish Fork City GIS Department. Mapleton City Zoning information obtained from Mapleton City and prepared as GIS metadata by Charter Oak Environmental Services, Inc. Data Revision Year: 2000

Mapleton and Spanish Fork City Zoning Classification Map

FIGURE 6-6

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Approximate Scale

N

0.3 0 0.3 0.6 Miles

1:45000

Land use metadata adapted from the Department of Natural Resources, Division of Water Resources: Land Use | Water Related Use (QD024NR.LUWRU), Revised August 30, 1997.

Mapleton and Spanish Fork City Land Use Classification Map

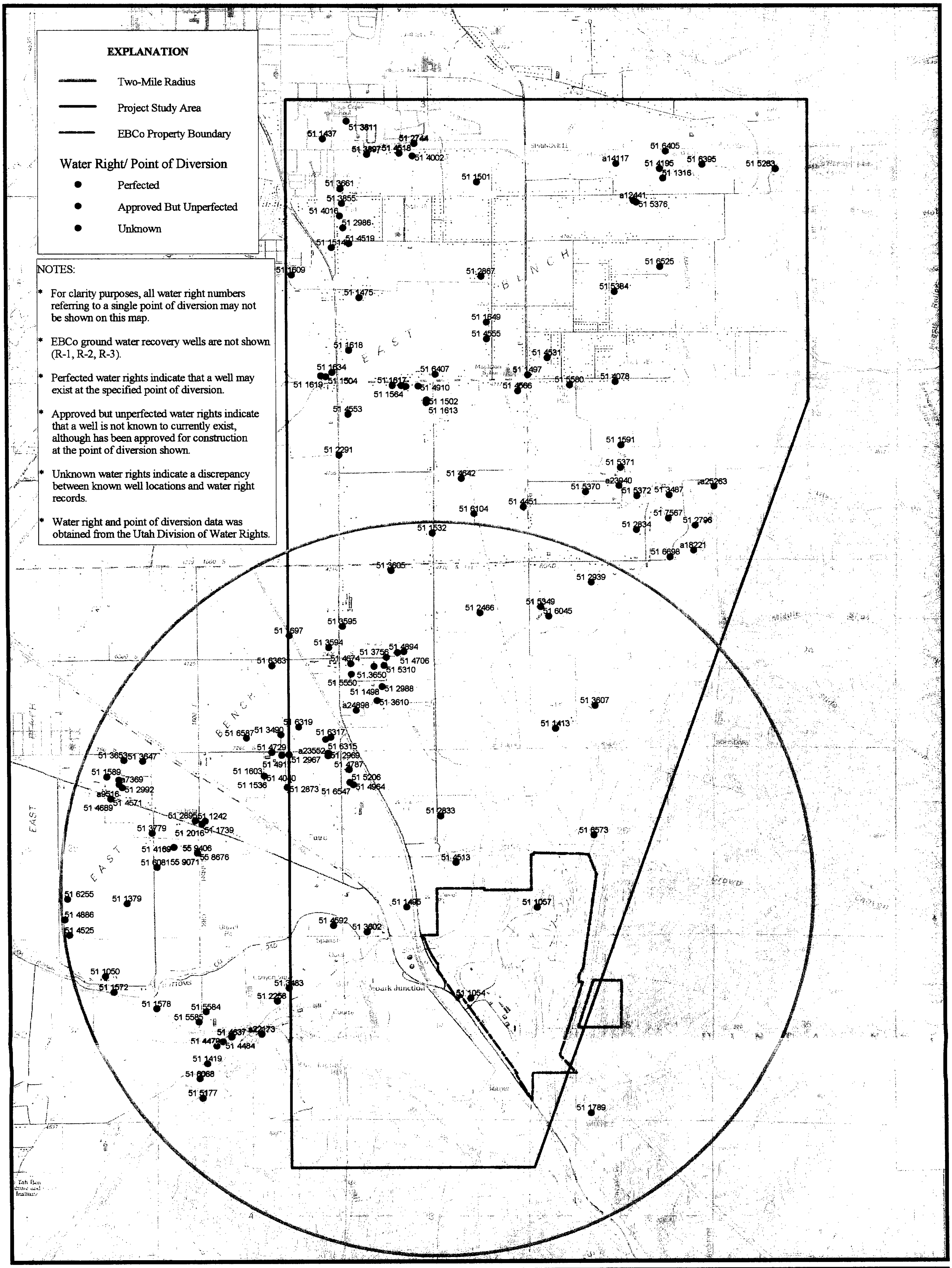
FIGURE 6-7

6.1.5 Ground Water Withdrawals

A summary of underground water rights located within a two-mile radius of the Plant was obtained from the Utah Department of Natural Resources, Division of Water Rights (DWR). The DWR database includes both perfected and approved but unperfected water rights. Perfected water rights indicate that infrastructure (a well and delivery equipment) has been installed and the water has been put to beneficial use. Unperfected water rights have been approved but have not been developed to allow beneficial use of the water. The record of perfected water rights for ground water generally indicates the presence of private and municipal wells in the area. The location of a well is called the "point of diversion." It is common that several water rights may reference a single point of diversion. For instance, there are thirty-five individual water rights, which reference the Westwood well as the point of diversion. Therefore, every perfected water right does not necessarily represent the presence of a well.

Because of the distribution of ground water quality impacts, particularly in those areas north of the Plant site, water rights information was gathered from within the study area although outside of the two-mile radius specified in the regulations. The points of diversion, representing well locations, are displayed in Figure 6-8. Points of diversion, reflecting perfected water rights are colored blue. Points of diversion representing approved but unperfected water rights are colored green and water rights having an undetermined status are colored magenta. A unique water right number identifies each point of diversion. A table summarizing available and relevant information for each well (location, owner, construction date, depth, flow rate, aquifer screened, etc.) is provided in Appendix A. A nearly complete compilation of well logs from the study area in 1989 can be found in Engineering Science (1990).

Based on the water rights information obtained from the DWR, there are a total of 109 established points of diversion (wells) present within the combined area bounded by the two-mile radius circle and the study area (see Figure 6-8). An additional seventeen water rights have been approved but have not been perfected and the status of two water rights are undetermined. Of this total, eighty-seven established points of diversion (wells) are located within the study area. Sixty-six of these wells are open to the regional unconsolidated aquifer, ten are open to the perched Mapleton Bench ground water system and one is open to the bedrock aquifer. Eleven additional water rights have been approved within the study area but have not been perfected and the status of one water right remains undetermined. Five municipal wells (Mapleton No. 1, Westwood, Seal, Carneseca and Olsen) and one private irrigation well (Orton-23) are the highest capacity wells in the study area and are open to the regional unconsolidated aquifer. Each of these wells is capable of producing between approximately 750 and 1,500 gpm. The remaining 60 wells within the study area that are open to the regional unconsolidated aquifer are privately owned and are of smaller design. These wells are generally used for domestic, stock watering or smaller-scale irrigation purposes, and typically produce between 20 and 50 gpm. According to DWR records, perfected water rights for wells open to the regional unconsolidated aquifer within the study area have been approved for a combined total flow rate of approximately 11,700 gpm (18,800 acre-feet per year).



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Approximate Scale
N
1000 0 1000 2000 Feet
1:30000

Ground Water Usage Map

FIGURE 6-8

6.2 Surface Water

6.2.1 Perennial Streams

There are three perennial streams within the study area. The Spanish Fork River and Hobble Creek are the two largest (by volume) perennial streams in Southern Utah Valley and bound the study area to the south and north, respectively. Maple Creek, located roughly due east of the center of Mapleton is a minor perennial stream that enters the study area from Maple Canyon. Stream locations are illustrated on Figure 6-3.

6.2.1.1 Spanish Fork River

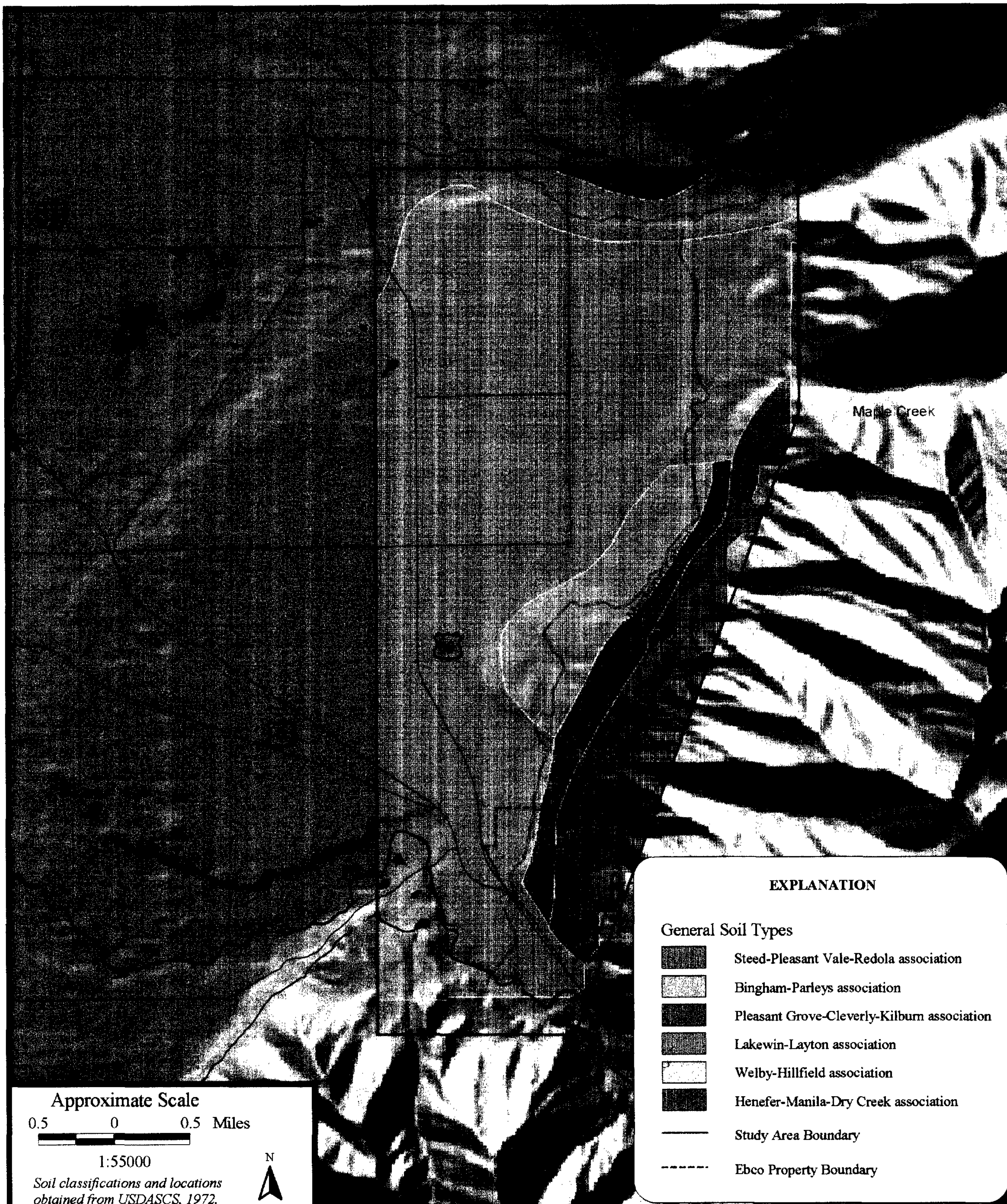
The Spanish Fork River is the largest stream in the region and contributes approximately 75 percent of all perennial stream flow that enters Southern Utah Valley. On average, approximately 60 percent of the flow is derived from the 652 mi^2 watershed and the remaining 40 percent is diverted from the Strawberry Reservoir in the Colorado River Basin (Cordova, 1970). The average annual flow of the Spanish Fork River from 1949 to 1990 was estimated to be 174,900 acre-ft (Brooks and Stolp, 1995). According to the USGS web site, the average daily minimum, mean and maximum flows for the Spanish Fork River are 79 ft^3/s, 225 ft^3/s and 406 ft^3/s, respectively. The extremes during this same 72-year period were 5,000 ft^3/s on May 15, 1984 and 5.8 ft^3/s on December 15, 1964 (USGS, 2000). During the irrigation season, most of the water is diverted at the canyon mouth into irrigation canals. According to Brooks and Stolp (1995), the average annual diversion to canals from the Spanish Fork River is 105,100 acre-ft/yr. This water is diverted to seven major irrigation canals that serve approximately 47,000 acres in Southern Utah Valley.

6.2.1.2 Hobble Creek

Hobble Creek is the second largest perennial stream in the area and contributes approximately 15% of all perennial stream flow entering Southern Utah Valley. The average annual flow of Hobble Creek from 1949 to 1990 was estimated to be 33,900 acre-ft (Brooks and Stolp, 1995). Nearly all the water in Hobble Creek is diverted for irrigation purposes during the irrigation season. Hobble Creek is diverted to seven major canals that service approximately 9,200 acres near Springville (Brooks and Stolp, 1995).

6.2.1.3 Maple Creek

Maple Creek had an estimated average annual flow of 1,800 acre-ft for the 1949 to 1990 time period (Brooks and Stolp, 1995). These same researchers indicate that Maple Creek is almost entirely diverted above the mouth of Maple Canyon and very little of the water enters the valley in the stream channel.



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Major Soil Associations

FIGURE 6-9

from quartzite. Minor soils in this association include the Pleasant View and Dagor soils. Soils in this association have moderate to rapid permeability.

3. The Welby-Hillfield association is described as well-drained, gently sloping to steep loamy soils on high lake terraces. The Welby soils occur in swales and on slopes that generally face north and east. They have a surface layer of silt loam. The Hillfield soils occupy ridges, steeper slopes and slopes that face south and west and have a surface layer of silt loam. Minor soils of this association include the Taylorsville and McMurdie soils. The Welby and Hillfield soils are moderately permeable. This association is found in the general area of elevated topographic bench present in the southeastern portions of the study area.

4. The Bingham-Parleys association consists of well-drained, nearly level to moderately sloping, gravelly, loamy soils on intermediate and high lake terraces. The Bingham soils consist of gravelly or cobbly heavy loam or sandy clay loam to a depth of about twenty inches and are very gravelly and sandy below. Bingham soils occur near the mouths of the canyons on the upper part of lake terraces. The Parleys soils have a loam or silty clay loam surface layer and a silty clay loam subsoil. Permeability is slow to rapid in both soil types. Minor soils of this association primarily consist of the Timpanogos, Kidman, Dagor and Hillfield soils. This association is present primarily in the Mapleton Bench area of the study area (see Figure 6-14).

5. The Steed-Pleasant Vale-Redola association is described as well-drained, nearly level to gently sloping, gravelly, loamy soils on flood plains and alluvial fans. This association is found in the flood plain of Hobble Creek in the northern part of the study area. The Steed soils are near stream channels and have a gravelly sandy loam surface layer and are underlain by very gravelly loamy sand. Pleasant Vale soils occur on the low part of alluvial fans and on flood plains. They have a loam surface layer and are underlain by loam and very fine sandy loam. The Redola soils have a loam texture. Minor soils in this association include the Provo, Keigley and Pleasant View soils.

6. The Lakewin-Layton association is described as well-drained and moderately well-drained, nearly level to moderately steep, gravelly, sandy, and loamy soils on lake terraces and terrace escarpments. This association is present in the northeast corner of the study area and is developed in lake deposits. The Lakewin soils are well drained and have a gravelly fine sandy loam texture to a depth of twenty inches and very gravelly loamy texture below. The Layton soils are well drained or moderately well drained with a loamy fine sand or fine sandy loam surface layer and are underlain by loamy fine sand. Minor soils in this association include the Preston and Bramwell soils.

Detailed mapping illustrating the distribution of soil types in the study area is available in the Soil Survey of Utah County, Utah (USDASCS, 1972).

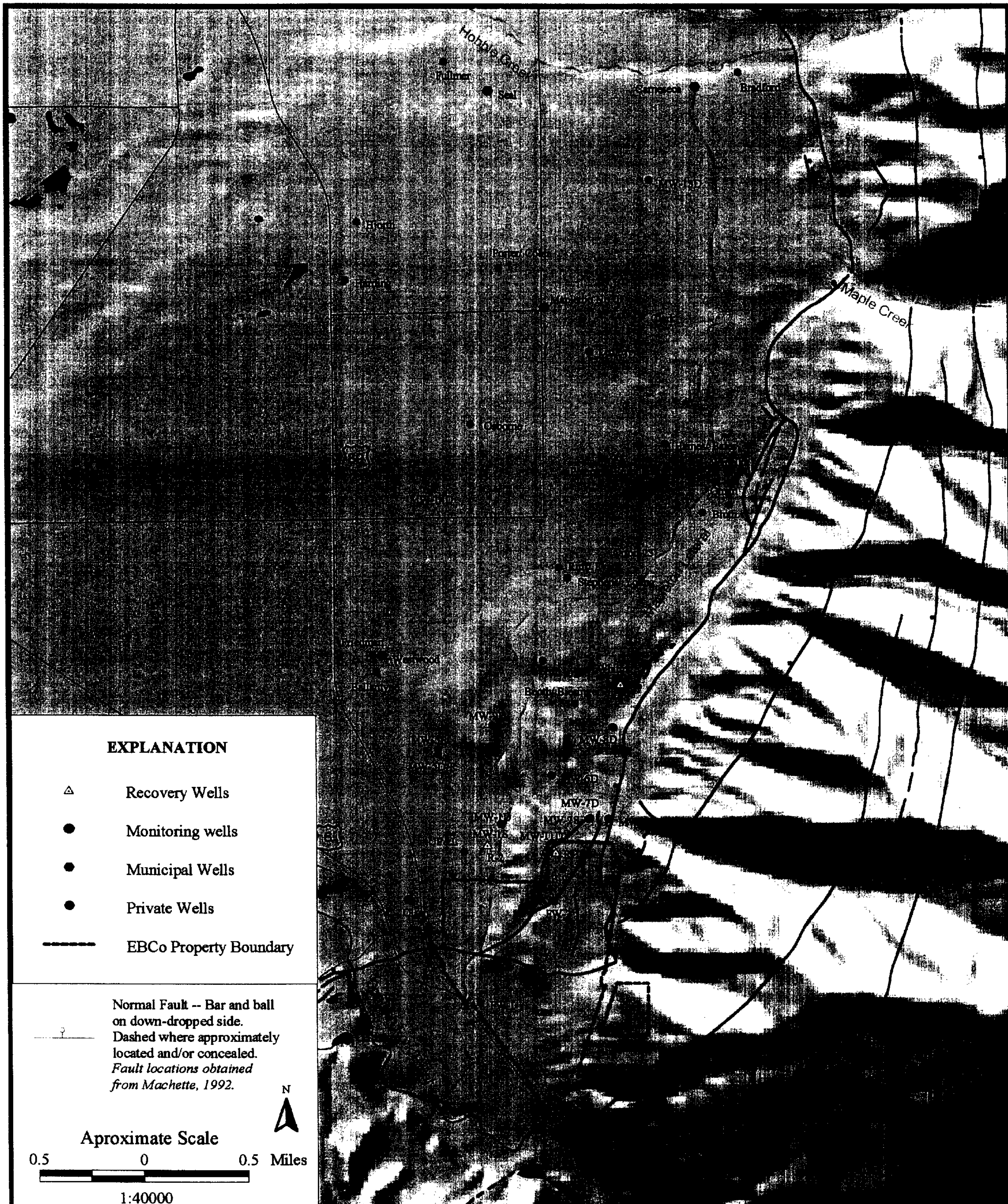
6.4 Study Area Geology

The site is located in a geologically complex setting characterized by overlapping and highly variable depositional environments (lacustrine, alluvial, fluvial) and faulting associated with the Wasatch Fault Zone. A discussion of the general geologic structure, bedrock geology and unconsolidated deposits of the study area is presented herein.

6.4.1 Structural Geology

The Wasatch Fault Zone is the most significant structural feature in the study area. Machette (1992) mapped major and minor faults in the study area as illustrated in Figure 6-10. The Wasatch Fault Zone consists of regional north-south trending branching, braided and en echelon faults; east-west trending faults; and, lesser magnitude northeast-southwest trending faults (ES 1990). The faults displace Oquirrh Formation and North Horn Formation bedrock and Tertiary and Quaternary aged sedimentary deposits. This is an active fault system originating in the Tertiary period and continuing to the present day. The impressive fault scarps and triangular faceted bedrock spurs present at the base of Spanish Fork Peak are visible indicators of the active fault system. The main trace of the Wasatch Fault trends north to south along the eastern margin of the study area at the base of the Wasatch Mountains. The Wasatch Fault is a normal fault separating tertiary and quaternary age unconsolidated deposits on the down dropped side to the west from the Oquirrh Formation bedrock to the east. There has been at least 13,000 feet of composite displacement as evidenced by a deep exploration well in Southern Utah Valley (Davis 1983). The fault dips west toward the valley at 30 to 50 degrees (Davis, 1983). The main fault takes a 100^{o} turn to the west across the plant property before continuing its general north-south trend.

Several lesser, northeast-southwest trending faults are mapped as being present in the unconsolidated deposits and Oquirrh Formation bedrock (Machette, 1992). Of particular interest to this discussion are the faults in the unconsolidated materials in the northeast portion of the Plant. As seen on Figures 6-10 and 6-11, these form a triangular shaped area bounded by the north-south trending Wasatch Fault to the east, the east-west trending Wasatch Fault to the south and the northeast-southwest trending antithetic faults in the unconsolidated deposits to the west. The interior of the triangle, containing the northeast portion of the facility where process wastewaters were historically managed, is a graben formed by the boundary faults described above. These faults may influence ground water movement in this area. The presence of solutes in MW-11D, R-1 and B-9 (historic data from B-9 indicated low concentrations of nitrate) indicate that the faults probably are not impermeable barriers. ES (1990) indicated that low permeability clay and silt layers present within the graben dip slightly to the east as a result of back-rotation caused by the local faulting. These dipping clays will affect the direction of ground water movement in perched ground water zones present in this area.



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Faulting

FIGURE 6-10

6.4.2 Bedrock

Bedrock present in the area consists of two formations, the Pennsylvanian Oquirrh Formation and the Cretaceous North Horn Formation.

6.4.2.1 Oquirrh Formation

The Oquirrh Formation consists of a thick sequence of massive interbedded limestone and sandstone comprising the bedrock of the Wasatch Mountains to the east of study area, specifically Spanish Fork Peak. Davis (1983) describes the Oquirrh Formation as "...dark gray to black, thin- to thick- bedded cherty limestone with a few quartzite beds" overlain by a "... gray to tan limy quartzitic sandstone, tan quartzite, and gray to black limestone or cherty limestone". Several exposures of the Oquirrh Formation are present in the vicinity of the study area. In Phase Ia of the hydrogeologic investigation, two road cut exposures in Spanish Fork Canyon and two relatively small outcrops in Crowd Canyon were mapped and limited bedrock coring was performed above the Facility. The purpose of the Phase Ia study was to evaluate if faulting or fractures in Oquirrh formation bedrock associated with the Wasatch Fault at the edge of the basin fill deposits could have acted as a conduit for nitrate migration to the north as postulated by ES (1990). A detailed evaluation of the Phase Ia investigation results, photographs, stereo plots of fracture orientation data and crude bedrock hydraulic conductivity estimates are presented in the Phase Ia Summary Report (Dames and Moore, 1991). Dames and Moore concluded that although north-northeasterly orientated fractures and shear zones were present, northerly migration in the fractured bedrock was unlikely. Subsequent sampling of wells open to the bedrock aquifer (Oman and MW-12D) confirmed that the bedrock aquifer was not a solute migration pathway (Owens Western, 1996).

6.4.2.2 North Horn Formation

Davis (1983) described the Upper Cretaceous/Lower Paleocene North Horn Formation as a mostly red conglomerate with subordinate pale red shale and siltstone. The North Horn Formation is well exposed along the main facility roadway and is characterized by a rusty red color in outcrop. Surface exposures of North Horn Formation on the Plant site as mapped by Machette (1992) are illustrated in Figure 6-11 (map symbol P_EKs). At the facility, the North Horn Formation consists primarily of red to orange poorly consolidated, well-rounded cobbles and boulders in a sand and silt matrix. The red colored materials are unique to the North Horn Formation in the study area and have been encountered in only one other boring constructed in the study area. The formation is estimated by Rawson (1957) to be 400 to 500 feet thick in Spanish Fork Canyon.

Soil Borings SB-4 and SB-5 were installed just north (down-dropped side) of the east-west trace of the Wasatch Fault across the Plant site as shown in Figure 6-11 (see map pockets at end of document). SB-4 was advanced to total depth of 393 feet and SB-5 was advanced to a total depth of 500 feet. A red clay, gravel and sand mixture, indicative of the North Horn Formation was encountered at a depth of 93 feet below grade in SB-4. Red clays, silts, sands and gravels are present to the boring completion depth indicating that the thickness of the North Horn Formation is at least 300 feet at the location of SB-4. The North Horn Formation was intercepted at a depth of 114 feet in SB-5 and continued to the boring completion depth of 500 feet indicating that the thickness of the North Horn formation is at least 386 feet at the location of SB-5.

Approximately 230 feet of red clay mixed with gravel were also intercepted at a depth of three feet below the ground surface during the construction of Facility Well No. 2 (FW-2). Considering the location of FW-2 within the Wasatch Fault Zone and the unstable nature of the North Horn Formation in the area, ES (1989) postulated that the red clays and gravels encountered at FW-2 represented a slump feature of North Horn Formation that slid into and was surrounded by younger lacustrine and fluvial deposits. The red clays observed in the FW-2 boring may also be eroded from the adjacent North Horn Formation bedrock.

Based on the area of North Horn Formation bedrock mapped by Machette (1992), the North Horn Formation is covered by a relatively thin mantle of interbedded clays, sands and gravels south of the east-west trace of the Wasatch Fault and east of the steep topographic escarpment present at the Plant site. The North Horn Formation bedrock was not penetrated by soil boring SB-3 which was advanced to a depth of 390 feet (see Figure 6-11).

6.4.3 Unconsolidated Deposits

Southern Utah Valley is a graben formed by Tertiary aged normal faulting. The Wasatch Fault Zone forms the eastern margin of the graben and faulting on the east side of West Mountain forms the western margin (Brooks and Stolp, 1995). According to Cordova (1970), valley fill materials consist of Tertiary to Quaternary-aged unconsolidated to cemented and compacted lacustrine, alluvial fan and fluvial deposits derived from erosion of the Wasatch Mountains to the east. Some researchers estimate that these materials may extend to a depth of at least 18,000 feet in the Spanish Fork area (Brooks and Stolp, 1995). The lithified and compacted Tertiary deposits are thought to occur at depths of greater than approximately 1,500 feet (Brooks and Stolp, 1995). No subsurface information is available for depths greater than 700 feet in the study area. Gates (1987) indicates that in most valleys in the Great Basin the unconsolidated sands and gravels that readily yield water are within the upper 700 to 1,500 feet of materials. Cementation and compaction generally reduce the permeability of materials below those depths. For these reasons and the fact that production wells in the study area are not more than 700 feet deep (most are less than 550 feet), this discussion will be limited to the upper 700 feet or so of materials.

The stratigraphy of these deposits is complex, reflecting a variety of interacting depositional processes including lacustrine deposition and reworking of materials during transgressive and regressive cycles of Lake Bonneville, deltaic and fluvial deposition of materials related to the Spanish Fork River and Hobble Creek and alluvial fan deposition and colluvial deposition from erosion of the Wasatch Mountains. According to Brooks and Stolp (1995), the unconsolidated basin-fill generally consists of interbedded and lenticular deposits of gravel, sand, silt and clay. Lacustrine, alluvial and colluvial processes sorted the deposits according to the level of Lake Bonneville and the location of streams at the time of deposition. The various depositional processes formed alternating and interfingering layers and lenses with substantial vertical and lateral heterogeneity. The stratigraphy is most complex adjacent to the basin edge where the four major depositional processes were at times present. Alluvial and minor colluvial processes were predominant along the mountain front resulting in the deposition of poorly to well sorted clay, sand and gravel deposits. Deposits along the basin edge are heterogeneous and rapid lateral and vertical changes in subsurface materials are observed. Faulting in the Wasatch Fault Zone adds to the complexity. Westward, lacustrine processes deposited materials or reworked the alluvial and colluvial materials resulting in the deposition of better-sorted sands and gravels with interbedded clay layers. In the Mapleton Bench area, laterally continuous sequences of well-sorted interbedded sands, gravels and clays appear to be present. West of the study area and in the vicinity of Utah Lake, the basin-fill deposits consist almost entirely of silts and clays deposited in a quiescent lacustrine environment (Brooks and Stolp, 1995). Thick deposits of sands and gravels are found along the stream channels and deltas of Hobble Creek and the Spanish Fork River. An in depth review of the unconsolidated subsurface geology of the study area is presented in Section 6.5.1.2 of this document.

6.4.3.1 Surficial Geology

The surficial geology of the study area, as mapped by Machette (1992) is presented in Figure 6-11, found in the map pockets at the end of this document. Machette mapped the surficial geology based on genesis and age. The three primary modes of formation in the study area were lacustrine, alluvial and colluvial depositional processes. Machette's age classification is based on the relationship to the Bonneville lake cycle, which represents the major oscillations in water level of the last deep lake in the Bonneville Basin. Machette divided these deposits into three age groups in the study area.

1. Deposits that post-date the Bonneville Lake Cycle. The deposits are Holocene or Pleistocene in age and according to Machette are less than 10,000 years old.

2. Deposits contemporaneous with the Provo shoreline and the regressive phase of the lake cycle. These deposits are Pleistocene in age and according to Machette are between 10,000 and 14,500 years old.

3. Deposits contemporaneous with the Bonneville shoreline and the transgressive phase of the lake cycle. These deposits are Pleistocene in age and according to Machette are between 14,500 and 32,000 years old.

Lacustrine deposits are the predominant type of materials found in the study area and consist of gravels, sands, silts and clays deposited in response to the Bonneville lake cycle. Lacustrine gravels (lpg, lbg, lpd) were typically deposited in relatively highenergy environments such as beach ridges, spits and deltas. Lacustrine sands (lps, lbs, lpd) were deposited in relatively shallow water near shore and represent beaches, spits and deltas. Lacustrine silts and clays (lpm, lbm) were deposited in quiescent waters associated with deep-water basins, sheltered bays between headlands or in lagoons behind barrier bars.

Alluvial deposits in the study area consist of variable amounts of gravel, sand, silt and minor amounts of clay deposited by perennial and intermittent streams. The materials in these deposits are commonly well sorted and have a clast-supported framework. The stream alluvium (alp, al1, al2) is typically better sorted and more rounded than equivalent aged alluvial fan deposits (afy, af1, af2, af3). Large amounts of stream alluvium are associated with the stream channel and delta deposits of the Spanish Fork River and Hobble Creek with lesser amounts found near the mouths of the ephemeral drainages of the Wasatch Range. The alluvial fan materials are generally restricted to the area within 2,000 to 3,000 feet of the mountain front.

Colluvial deposits are mapped in only a few locations within the study area and generally consist of poorly sorted to unsorted landslide deposits reflecting the materials from which they were derived. Colluvial deposits (ca, cfs) are of Holocene to middle Pleistocene in age.

The low rounded hills of the high topographic bench along the mountain front consist of and are underlain by lacustrine silts and clays of the transgressive Bonneville phase of the lake cycle (lbm). These silt and clay deposits commonly overlie sandy to gravelly deposits indicating deposition in increasingly deeper water of a transgressive lake. They are generally bounded conformably to the east by sands and gravels (lbs and lbg) representing the shoreline of the Bonneville phase of the lake cycle. The lacustrine deposits in this area are incised and overlain in places by stream alluvium associated with the regressive Provo phase of the lake cycle. Alluvial fan deposits (ay, a1, a2, a3) generally represent the youngest materials found along the mountain front. Machette mapped numerous distinct alluvial fan deposits primarily associated with the major canyons of the Wasatch Range (i.e. Crowd Canyon, Big Slide Canyon, Middle Slide Canyon, Maple Canyon). These alluvial fan deposits overlie or are contemporaneous with the stream alluvium and lacustrine deposits in this area. A narrow sinuous band of undivided colluvium and alluvium (ca) is mapped in the southern part of the study area extending north from the mouth of Spanish Fork Canyon to the vicinity of the Westwood well. It lies immediately west of the steep escarpment forming the western boundary of the elevated topographic bench and may reflect gravity-induced deposition from this steep escarpment. A narrow strip of fault scarp alluvium (cfs) is mapped along the west side of the Wasatch Fault (see inset on Figure 6-11). It does not appear on the smaller scale geologic map of the study area, but its nearly ubiquitous presence on the larger scale geologic map of the Plant site suggests that it is likely to be present along much of the length of the Wasatch Fault in the study area.

In the center of the study area there is blue triangular shaped area indicating lacustrine sand (lps) and lacustrine silt and clay (lpm). The sand represents the shoreline of the

Provo phase of the Bonneville lake cycle and overlies the silt and clay (lbm) of the Bonneville phase of the lake cycle. The lacustrine silt and clay to the west of the sand also commonly overlies the silt and clay of the Bonneville phase of the lake cycle indicating deposition in the decreasing water depth during the regressive Provo phase. The Provo phase sand, silt and clay deposits in the study area are overlain by stream alluvium (alp) and deltaic deposits (lpd) associated with the Provo phase of the lake cycle. Machette indicates that the stream alluvium overlies the deltaic deposits in this area. The northeast-southwest orientated stringers of Provo phase sands (lps) probably represent offshore spits or bars present during the Provo phase of the lake cycle. The area of Provo phase stream alluvium and deltaic deposits roughly corresponds with the area of the Mapleton Bench.

6.5 Study Area Hydrogeology

In addition to the data and information gathered over the course of the hydrogeologic investigation, three primary information sources were used to characterize the hydrogeology of the study area. Mifflin (1988) provides information about regional aquifer systems and ground water flow in the Great Basin. Brooks and Stolp (1995) provide detailed information about Southern Utah Valley, and is the primary reference used to establish the water balance for the hydrogeologic system in the study area and provides some aquifer transmissivity data. Cordova (1970) also provides some aquifer transmissivity data.

6.5.1 Ground Water Systems

Two main, regional aquifer systems are present in the study area: 1) the bedrock aquifer consisting of Oquirrh Formation limestone and sandstone; and, 2) the unconsolidated aquifer consisting of Pleistocene to Holocene aged clays, silts, sands and gravels. Several zones of perched ground water, most notably the Mapleton Bench ground water system, are also present in the study area. The unconsolidated regional aquifer system is of primary concern to this investigation. The bedrock aquifer, while not a solute migration pathway (Owens Western, 1996), is important to this evaluation because it represents an important hydrogeological boundary in the study area and contributes locally variable recharge to the regional unconsolidated aquifer.

6.5.1.1 Bedrock Aquifer

The bedrock aquifer consists of Oquirrh Formation bedrock along the eastern margin of the study area. This aquifer lies mostly east of the main trace of the Wasatch Fault; however, the bedrock aquifer was penetrated at depth by the Oman private well in the northeast portion of the study area. The Oman well is located within the Wasatch Fault Zone and the bedrock aquifer was overlain by approximately 260 feet of mostly dry unconsolidated deposits, to an elevation of about 4,587 feet.

Two soil borings (SB-4 and SB-5) penetrating the North Horn Formation to depths of up to 500 feet at the Plant site did not encounter significant saturated conditions. Due to the lack of saturated materials, the North Horn Formation is not considered to be part of the bedrock aquifer system in the southern portion of the study area.

Ground water is present and migrates within fractures, bedding planes, solution channels and pores in the rock itself. The permeability of the bedrock aquifer in the study area is not known. Falling head packer testing of a bedrock core hole performed during Phase Ia of the hydrogeologic investigation and reported by Dames and Moore (1991) was conducted in unsaturated conditions and are not considered to provide accurate hydraulic conductivity estimates of the bedrock aquifer. Burbey and Prudic (1991) provide a range of bedrock transmissivity estimates of between 200 ft^2/day to 800,000 ft^2/day for carbonate bedrock aquifers in the Great Basin. Burbey and Prudic constructed a regional numerical model of the Great Basin and through the model calibration process they arrived at a range of transmissivity values of between 500 ft^2/day and 155,000 ft^2/day. These are gross approximations and actual transmissivity values may vary considerably from location to location.

Two wells are known to penetrate the Oquirrh Formation bedrock in the study area.

1. The Oman well is a private irrigation well installed in 1995. This well penetrates the bedrock aquifer at a depth of approximately 260 feet below ground surface. The completed well depth is 565 feet. Approximately 65 feet of red shale, interpreted as North Horn Formation, overlies Oquirrh Formation limestone in this well. The bedrock portion of the well was completed as an open hole with no well casing or screen. The Oman well is a flowing artesian well. Upon completion of the unconsolidated portion of the well in the North Horn Formation, the well driller reported an artesian flow rate of approximately 1 gpm. The driller reported a 100 gpm flow rate for the completed well (Oquirrh Formation). A pressure head reading taken from the top of the sealed well casing was 50 psi indicating a potentiometric head elevation of approximately 4,960 feet. This water level elevation is nearly 210 feet higher than the water level measured in the adjacent Bluth well and more than 300 feet higher than water levels measured in the Orton-23 and Young wells which all screen the regional unconsolidated aquifer in the area.

2. MW-12D is a monitoring well installed at a 70° angle (20° from vertical) into Oquirrh Formation bedrock just north of the Plant. Drilling and well construction details for MW-12D are presented in the Supplemental Hydrogeologic Investigation Report (Owens Western, 1996). The boring was advanced to a total vertical depth of 202 feet and the well was constructed at a vertical depth of approximately 143 feet. Bedrock was encountered at a vertical depth of approximately 107 feet and continued to the base of the boring. Upward vertical gradients on the order of 1 ft/ft were observed during drilling operations. Water levels in this well have ranged from approximately 4,950 to 4,930 feet over the past five years. The water level elevations measured in MW-12D are

approximately 120 to 150 feet higher than water levels measured in the regional unconsolidated aquifer immediately west of MW-12D.

6.5.1.2 *Unconsolidated Regional Aquifer*

Historically, Cordova (1970) identified four main aquifers in Southern Utah Valley and the study area. In descending order from the surface they are the unconfined Lake Bonneville Group, the shallow (upper) Pleistocene artesian aquifer, the deep (lower) Pleistocene artesian aquifer and the Tertiary artesian aquifer. According to Cordova (1970) the base of the Lake Bonneville group aquifer consists of fine grained, lower permeability materials that form a confining bed above the artesian part of the regional ground water system. Laterally extensive deposits of less permeable silts and clays separate the three artesian aquifers identified by Cordova.

Based upon an extensive review of lithologic information from well logs in Southern Utah Valley, Brooks and Stolp (1995) were unable to identify the four distinct, laterally extensive aquifers proposed by Cordova throughout Southern Utah Valley. For this reason, Brooks and Stolp (1995) consider the unconsolidated basin-fill deposits to be one main regional ground water system with varying horizontal and vertical permeability. Up until this point, consultants on this project have generally adopted and used the aquifer designations and nomenclature defined by Cordova and have identified and described other aquifers in the area (i.e. Channel Aquifer, Whiting Unit, Hains Unit). While laterally extensive and vertically discrete deposits appear to be present in the central and western portions of the study area, this CAP adopts Brooks and Stolp's more recent conceptualization of a regional aquifer system in the unconsolidated basin fill deposits. The various aquifers identified by Cordova and various researchers involved in hydrogeologic investigation of the study area are better described as hydrostratigraphic units within the regional aquifer system. These hydrostratigraphic units are bounded laterally and vertically and are characterized by differing physical and hydraulic properties. According to Brooks and Stolp (1995), horizontal and vertical water movement in the regional unconsolidated aquifer occurs mainly through the coarser deposits, and water in deeper deposits in the regional aquifer is not isolated from water in shallower deposits in the regional aquifer.

Brooks and Stolp (1995) presented a generalized conceptualization of the hydrogeologic system in the Southern Utah Valley. In their conceptual model, the Wasatch Fault separates the consolidated bedrock aquifer from the unconsolidated basin fill. The unconsolidated deposits consist of poorly sorted alluvium and colluvium adjacent to the mountain front grading westward into interbedded sand and gravel aquifers separated by discontinuous clay lenses. According to Brooks and Stolp (1995), unconfined conditions are present in the basin-fill materials near the mountain front and unconfined conditions also exist in roughly the upper 50 feet of saturated basin fill in the valley to the west. In Brooks and Stolp's conceptualization, the less permeable, interfingering silt and clay layers cause a reduction in vertical permeability and effectively confine the ground water in deeper sand and gravel deposits. Brooks and Stolp also show that perched ground water systems, such as the Mapleton Bench ground water system, are present. These perched ground water systems are shown to discharge to surface springs and to be separate from the regional aquifer system. Recharge to the unconsolidated regional aquifer system is primarily from losing streams, ephemeral drainages along the mountain front and inflow from the bedrock aquifer. The primary discharge area is west of the study area toward Utah Lake. Discharge is primarily to flowing wells, gaining streams, springs, Utah Lake and losses to evapotranspiration. Brooks and Stolp indicate downward ground water flow in the recharge area adjacent to the mountain front and horizontal ground water flow in the valley in the direction of and within the discharge area.

Brooks and Stolp appear to arrive at the conclusion that the regional aquifer becomes confined with depth based on the presence of flowing wells in the discharge area – the potentiometric surface of the confined aquifer is higher than the land surface and therefore flowing artesian wells are found in the discharge area. However, based on hydrogeologic research throughout the Great Basin, Mifflin (1968) presents an unconfined regional aquifer conceptualization and ground water flow system that also results in flowing wells in the absence of confined conditions. Figure 6-12 is adapted from Mifflin (1968) and presents an idealized sketch of fluid potential relationships in typical Great Basin ground water flow systems. Based on water level data, Mifflin recognized four major zones in typical Great Basin flow systems.

- The zone of recharge is present along the edge of a given basin adjacent to mountains. The recharge zone is characterized by downward vertical gradients and downward flow. Water levels from wells installed within the recharge zone typically decrease with decreasing well intake elevations as a results of decreasing fluid potential.

- The zone of lateral flow is usually quite extensive and lies between the recharge zone and the zone of increasing ground water potential. Flow within this zone is nearly horizontal. Water levels in wells completed at varying depths within the regional aquifer system will be similar, reflecting nearly vertical equipotential lines.

- The zone of increasing ground water potential is adjacent to the active discharge zone. Water levels for wells completed in this zone may rise above the water table as a result of increasing potential as the ground water moves toward the active discharge area. Flowing wells could be present in this zone if the fluid potential in a completed well is higher than the land surface elevation.

- The zone of active discharge is typically found in the center of the basin and may consist of a lake, playa and/or an area of phreatophytes. Wells completed in the regional aquifer in this

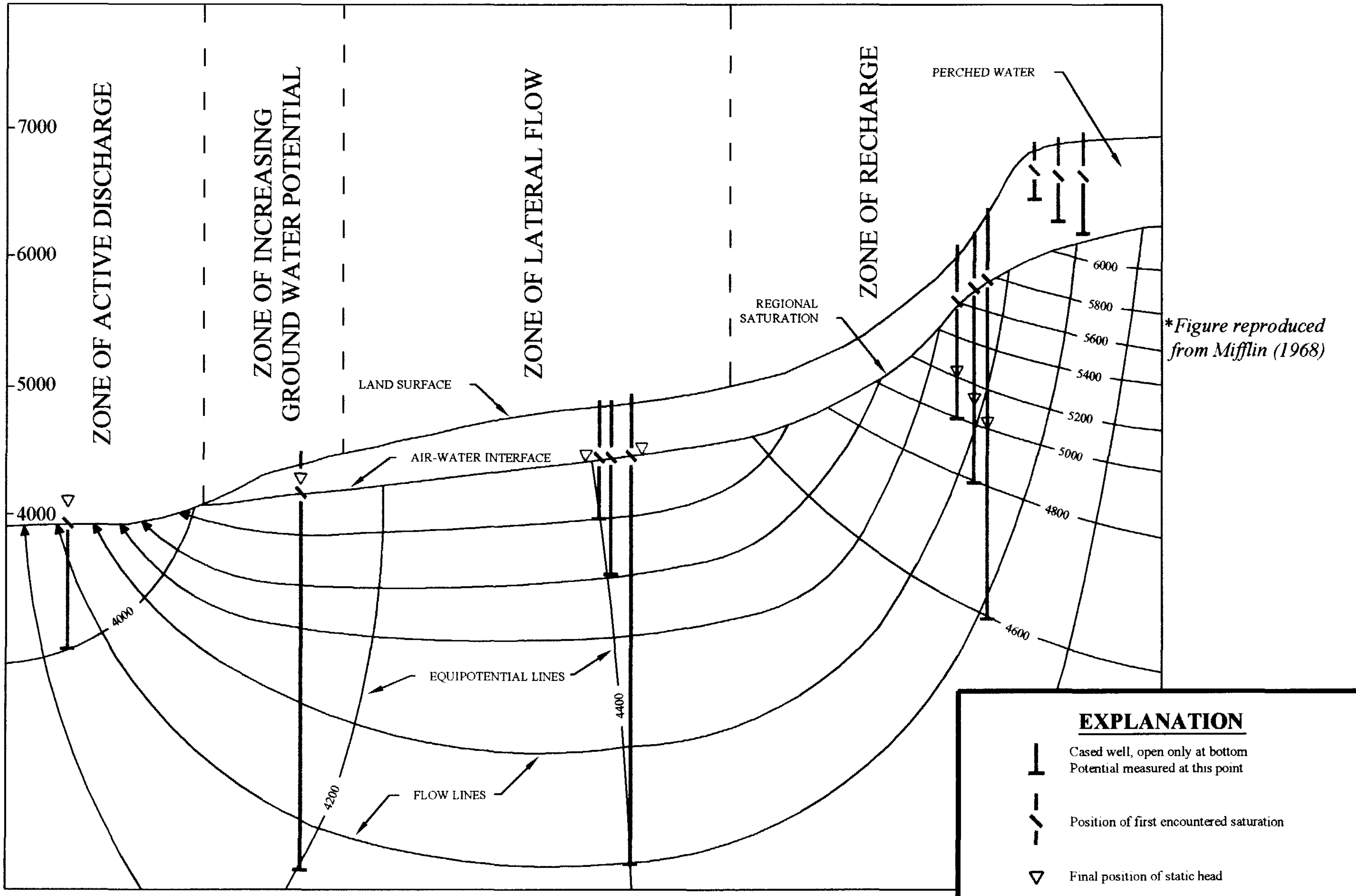

*Figure reproduced from Mifflin (1968)

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Idealized Conceptualization of Fluid Potential Relationships in the Great Basin

FIGURE 6-12

zone are likely to be flowing wells reflecting upward vertical flow resulting from increasing potential in the discharge area.

Mifflin's conceptualization of typical Great Basin flow systems is probably applicable to the study area. While localized confined or semi-confined conditions may be caused due to the presence of laterally extensive lower permeability confining units, it is appropriate to consider the regional unconsolidated aquifer system to be unconfined.

Lithologic and hydrogeologic data for the study area are available from several sources including twenty-nine monitoring wells, three recovery wells, over thirty well logs from private and municipal wells and from several soil borings. Much of this detailed information has been presented in previous reports submitted during the course of hydrogeologic investigation and will not be reproduced in this CAP. Although lithologic information is now available from soil borings and monitoring wells constructed at the Plant during the RFI, these new data are under evaluation and have not been incorporated into the cross-sections presented in this CAP. Once the RFI is completed and all lithologic data have been collected, revised or additional cross-sections incorporating these new data may be prepared. If updated or revised cross-sections are prepared, copies will be provided to DWQ in annual data summary reports. In accordance with previous work, subsurface materials have been classified according to the United Soil Classification System (USCS). Information from driller's logs available for municipal and private wells has been interpreted and classified according to the USCS.

Figure 6-13 (located in map pockets at the end of this document) presents ten cross-sections prepared to illustrate the general subsurface hydrogeology of the study area. The locations of the cross-section lines are illustrated in the top left corner of Figure 6-13. To ease the review and understanding of the hydrogeologic system, the unconsolidated materials have been grouped into four general categories as follows:

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Table 6-1: Categories of Unconsolidated Subsurface Materials

Category	USCS Classification	Characteristics
Clays	CL, OH	Materials consisting of clays, silty clays or sandy clays where more than 50% by weight finer than a No. 200 sieve.
Clay Mixtures and Silts	SC, GC, ML	Clayey sands, clayey gravels and clayey sand and gravel mixtures where more than 50% by weight are courser than a No. 200 sieve and $\geq$12% finer than a No. 200 sieve. Silts and very fine sands where more than 50% by weight are finer than a No. 200 sieve.
Silt Mixtures	SM, GM	Silty sands, silty gravels and silty sand and gravel mixtures where more than 50% by weight are courser than a No. 200 sieve and $\geq$12% finer than a No. 200 sieve.
Sands and Gravels	SW, SP, GW, GP	Poorly to well sorted sands, gravels and sand and gravel mixtures where more than 50% by weight are courser than a No. 200 sieve and 0 – 5% finer than a No. 200 sieve.

Clays deposits are colored dark gray and are characterized has having very low permeability. Clay units in the study area may act as local confining beds and as barriers to flow when juxtaposed with more permeable deposits. Clay units also underlie perched ground water in the study area.

Silts and clay mixtures are colored light gray and are characterized as having low permeability, similar to that of clays. Clayey sand and clayey gravel units in the study area may act as local confining beds and as barriers to flow when juxtaposed with more permeable deposits. These clay mixtures also underlie perched ground water systems

Silt mixtures are colored light blue and are characterized as having an intermediate permeability relative to the other classifications.

Sands and gravels are colored dark blue and are characterized as having high permeability. These sand and gravel deposits are the sources for most of the production wells in the study area. These are also the materials in which most ground water impacts have been identified and in which solutes would be expected to migrate most rapidly.

In those instances where a well pair is present at a given location (i.e. MW-1S and MW-1D), lithologic data from only the deep well is shown. Screened intervals are indicated in the cross-section in orange. The screened interval for the shallow well in a well pair is illustrated at the appropriate depth and labeled as to the well identification to distinguish it from a well with multiple screens. The approximate top of the zone of saturation of the regional aquifer, based on water level data collected during January 2000, is shown as a dashed magenta line.

Cross-section A-A' parallels the eastern margin of the study area from northeast corner of the Plant, starting at FW-2 and running north to the Carneseca well. The vertical and lateral heterogeneity characteristic of this portion of the study area adjacent to the mountain front is evident in this section. A sequence of interbedded clays, sands and gravels, with clays being the predominant material is observed below the northeast corner of the Plant. Just north of the plant boundary there is a thick sequence of permeable sands and gravels deposited in the alluvial stream channels and alluvial fans originating from Crowd Canyon. This represents one of the few locations in the study area where the vertical downward flow of ground water is relatively unimpeded by layers or lenses of lower permeability deposits. A sequence of interbedded clays, sands and gravels, similar to what is found below the Plant is observed at the location of MW-8D and extending northward. The finer grain, low permeability materials deposited in this area probably represent the Bonneville phase lacustrine silts and clays. A transition from the elevated topographic bench to the lower lying valley floor of the Mapleton Bench occurs between the location of the Whiting well and the Orton-23 well. The northward thinning of the Bonneville phase clay is the most notable change across this transition zone. A thick sequence of sands and gravels is observed in the northern portion of the cross-section at the locations of MW-13D and the Carneseca well. These highly permeable sands and gravels represent the stream alluvium and deltaic materials deposited by Hobble Creek. A laterally continuous near surface clay of the Bonneville phase lake cycle running from the R-3 location to MW-13D underlies the perched Mapleton Bench ground water system identified and described by Brooks and Stolp (1995). Lateral and vertical connectivity of more permeable deposits is demonstrated in this cross-section.

Cross-section B-B' parallels the approximate western margin of the study area from SB-3 in the south to the Fullmer well in the north. A thick sequence of highly permeable stream alluvium deposited by the Spanish Fork River and consisting primarily of gravel and sand is observed in the southern portion of the cross-section at SB-3, FW-1 and the O.B. Irrigation well (abandoned). The fault trace of the Wasatch Fault is illustrated just to the south of the O.B. Irrigation well. The inferred dip of the Wasatch Fault is 35°. The rapid change in lithology between the O.B. Irrigation and Olsen may reflect the emplacement of a thick sequence of stream alluvium at the location of the O.B. Irrigation well. Laterally extensive interbedded clay, sand and gravel deposits are present from the location of the Olsen well north the location of the Fullmer well. The upper most sand and gravel unit in this section represents the Provo phase stream alluvium and deltaic deposits. The upper fine-grained, lower permeability unit probably represents the Provo and Bonneville phase silt and clay deposits. The subsurface hydrostratigraphy along this cross-section is consistent with Cordova (1970). Water levels from the MW-5S/5D well pair indicate downward vertical flow at this location.

Cross-section C-C' crosses the Plant site in a southwest to northeast orientation from FW-1 to MW-7D. FW-1 penetrates the thick sequence of alluvial sands and gravels deposited by the Spanish Fork River. The North Horn Formation was penetrated by SB-4. The North Horn Formation is probably truncated to the west by the stream channel of the Spanish Fork River. Saturated conditions were not encountered in the North Horn Formation. The main trace of the Wasatch Fault is indicated just south of SB-4 with the up thrown side to the south of the fault and the down dropped side to the north. The Wasatch fault is illustrated as having a dip of 35°; however, the actual dip of the fault in this area is not known. The shallow clay present in B-7, B-10, B-11 and B-8 underlies the shallow perched ground water that was once present at this location. This level of the perched ground water dropped below screened intervals in the B-series wells shortly after wastewater discharges to the North Impoundment were stopped in 1991 (see discussion in Section 6.5.1.4). This shallow clay is truncated to the north by sands and gravels of the alluvial deposits emanating from Crowd Canyon. Cross-section C-C' demonstrates a ground water migration pathway from the shallow perched groundwater into the regional aquifer present in the Crowd Canyon Alluvium.

Cross-section D-D' runs south to north from R-1 to the Ruff/Evans well. The thick sequence of sands and gravels of the Crowd Canyon alluvial deposits are evident at the location of MW-6D. The total depth of these sands and gravels is not known. The lithology encountered at the Booth well location is of particular interest because it differs from materials observed immediately to the east at the location of MW-8D, R-3 and the Whiting well. It is possible that the gravel deposits intercepted at depth in the Booth well represent a buried stream channel originating from Crowd Canyon. This may act as a migration pathway for ground water movement and solute transport to the north as compared to the less permeable materials present to the east.

Cross-section E-E' was constructed west to east from the Westwood well to B-6. The approximate location of the north-south trending Wasatch Fault and the lesser southwest-northeast trending antithetic fault are shown. The former surface impoundments, wastewater conveyance channel and wastewater dispersion area are located within the graben formed by the local fault system. The shallow clays and clay mixtures present at B-10 and B-6 supported a former zone of perched ground water at this location. The upper thicker clays present in B-9, and possibly the antithetic fault, acted as a barrier to westward flow in the former perched ground water zone. The 300-foot sequence of interbedded clays and clay mixtures at B-9 and R-1 is typical of generally finer grained, lower permeability materials encountered on this topographic bench (with the exception of coarser deposits found at the canyon mouths such as the Crowd Canyon alluvial deposits). A transition to more laterally extensive interbedded clays, sands and gravels is observed westward across the section. The upper fine-grained, lower permeability unit observed at MW-5D and Westwood probably represents the clays and silts of the Provo phase of the Bonneville lake cycle.

Cross-section F-F' runs west to east from the Westwood well to MW-12D and crosses the Crowd Canyon alluvial deposits. MW-12 constructed at a 70° angle (20° from vertical) penetrates Oquirrh Formation bedrock. The approximate location of the main trace of the Wasatch Fault is illustrated. The thick sequence of alluvial sands and gravels associated with the Crowd Canyon alluvium are evident at MW-7D and MW-6D. A transition to a substantial thickness of clays and clay mixtures occurs between MW-6D and MW-9D.

Cross-section G-G' runs northeast from the Olsen well, across the Crowd Canyon alluvial deposits to MW-8D. The transition zone between the thick sequence of alluvial sands and gravels of the Crowd Canyon alluvium to the east and relatively greater quantities of interbedded clays and clay mixtures at the location of MW-1D and R-2 to the west is noted. A discontinuity is present between the locations of the MW-1S/MW-1D well pair and the UP&L wells. Water quality data from MW-1S and UP&L suggest a direct connection between these wells, yet R-2 located between these two wells has different lithologic, permeability and water quality characteristics. The Olsen well penetrates the thick sequence of interbedded sand gravel and clay that is typical of what is observed underlying the Mapleton Bench.

Cross-section H-H' runs northeast from the Westwood well to the Oman well. The North Horn and Oquirrh Formations are penetrated at depth by the Oman well. No saturated conditions were encountered in the thick sequence of sands and gravels above the bedrock. The uppermost, low permeability clay and clay mixture unit runs across the entire section and underlies the Mapleton Bench ground water system. This low permeability unit probably represents the Bonneville phase silt and clays of the Bonneville lake cycle. The deeper sand and gravel unit penetrated by the Bluth, Orton-23, Stephens, Ruff and Westwood wells is probably laterally continuous. The upper sand and gravel units between the Bluth and Ruff/Stephens location appear to be largely discontinuous. The apparent difference in lithology between the Stephens and Ruff wells may be due, at least in part, to differing interpretations made by the well drillers. Interbedded and laterally continuous clay, sand and gravel units are observed between the Stephens/Ruff location and the Westwood well. The North Horn and Oquirrh Formation bedrock aquifers are under flowing artesian conditions in this area.

Cross-section I-I' runs from the Hjorth well in the west to the Oman well in the east. It is our understanding that the Hjorth well was deepened to a total depth of 550 feet after the completion of the initial well. Lithologic information is not available for the deeper boring. The stratigraphy and characteristics observed for the Oman well are as described for cross-section H-H', above. The upper most clay and clay mixture unit running from Oman to Mapleton No. 1 underlies the Mapleton Bench ground water system. This low permeability unit probably represents the Provo and/or Bonneville phase silt and clays of the Bonneville lake cycle. Relatively thick deposits of sands and gravels with largely discontinuous interbedded clays and clay mixtures are observed in the Bluth, Frischknecht and Anderson wells and MW-13D. These may be related to alluvial deposits originating from Big and Middle Slide Canyons and Maple Canyon. Laterally continuous sand and gravel units separated by laterally continuous clays and clay mixtures are observed from the Mapleton No. 1 well to the Hjorth well in the west.

Cross-section J-J' is constructed through the Hobble Creek stream alluvium and deltaic deposits from the Alvey well in the west to the Carneseca well to the east. The upper most, low permeability clay and clay mixture unit is laterally continuous across the entire section and probably represents the Provo and/or Bonneville phase silts and clays of the Bonneville lake cycle. This upper clay underlies the Mapleton Bench ground water system. A thick sequence of relatively high permeability sands and gravels is found below the upper clay unit. Discontinuous lenses of clay mixtures are present within the massive sand and gravel deposits.

6.5.1.3 *Mapleton Bench Ground Water System*

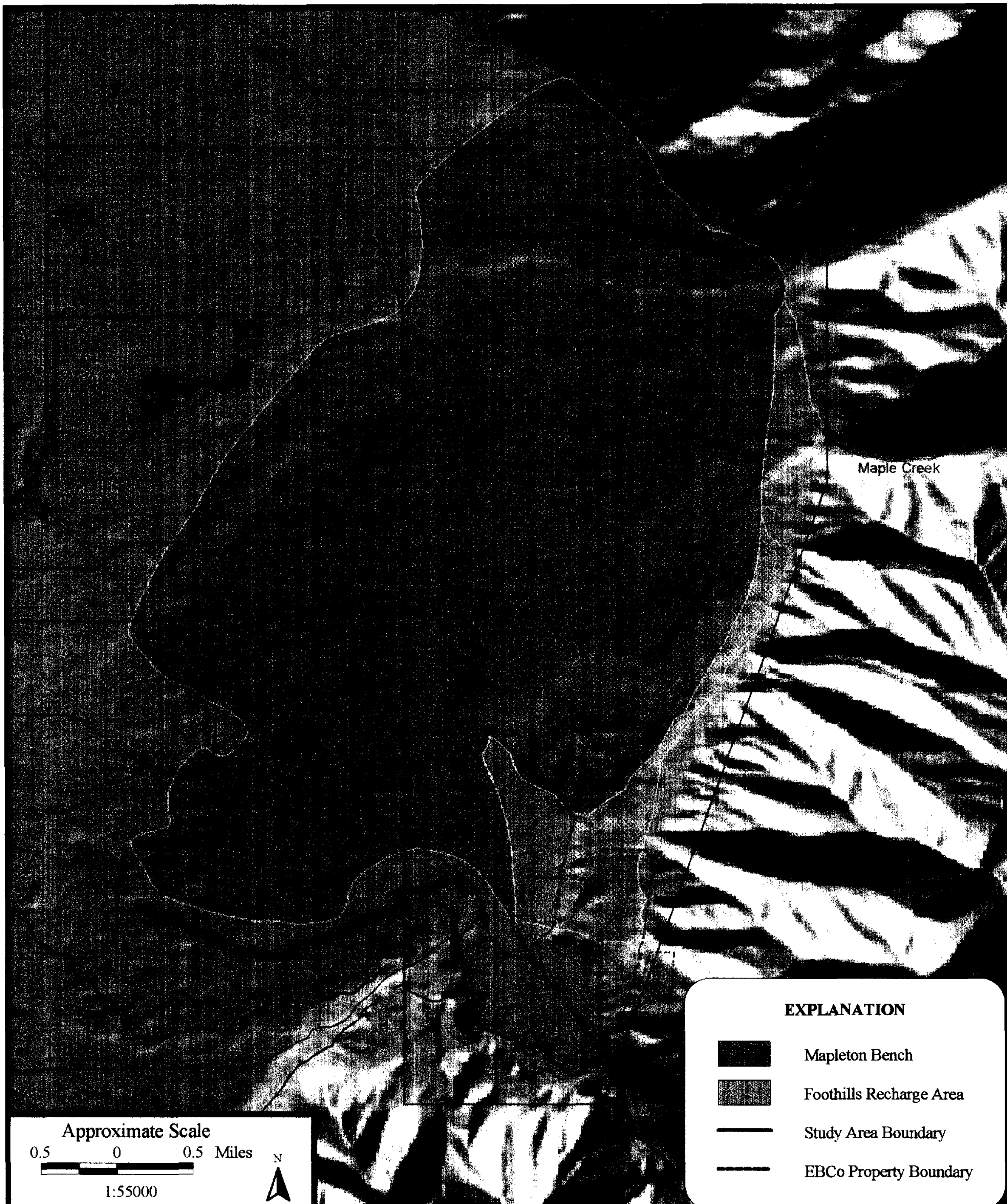
Brooks and Stolp (1995) identify a significant hydrogeologic feature they have termed the "Mapleton Bench system." According to Brooks and Stolp, the Mapleton Bench, between Hobble Creek and the Spanish Fork River, is underlain by at least one thick continuous layer of clay with some localized mixtures of sand and silt. This clay separates ground water in the unconfined, perched Mapleton Bench system from the underlying regional aquifer. Brooks and Stolp indicate that recharge to the Mapleton Bench system is from direct infiltration of precipitation, seepage from canals, septic tanks and applied irrigation water, and the underlying clay restricts vertical migration of this water. Perched ground water within the Mapleton Bench system moves laterally on top of the clay and discharges to springs at the margins of the Mapleton Bench and to Hobble Creek and the Mill Race Canal. Figure 6-14 illustrates the estimated lateral extent of the Mapleton Bench. The Mapleton Bench ground water system is a hydrogeologic feature located within and approximating the limits of the Mapleton Bench. The eastern and northern boundaries of the Mapleton Bench are inferred to be located at the facies change from Bonneville phase silts and clays to the Bonneville phase sands or along the main trace of the Wasatch Fault. The Mapleton Bench continues a short distance north of Hobble Creek. The Hobble Creek stream channel and related stream alluvium incises the Mapleton Bench, and based on the distribution of recharge to the main ground water system from stream leakage modeled by Brooks and Stolp (1995) along Hobble Creek, it is inferred that the stream channel of Hobble Creek cuts through the uppermost Mapleton Bench clay. This is consistent with Brooks and Stolp's conceptual model of the Mapleton Bench system, which shows springs from the Mapleton Bench ground water system discharging to Hobble Creek. The western boundary of the Mapleton Bench ground water system generally conforms to the topographic escarpment bounding the Mapleton Bench. According to Brooks and Stolp (1995), the Mapleton Bench is not present south of the Spanish Fork River. Brooks and Stolp's conceptual model indicates that the Mapleton Bench discharges to springs that flow into the Mill Race Canal, which is north of and roughly parallels the Spanish Fork River west of the study area.

As illustrated in Figure 6-14, there is a relatively narrow band of lacustrine sand and gravel and alluvial deposits immediately adjacent to the mountain front and east of the Mapleton Bench. This region is referred to as the "foothills recharge area." Water from intermittent and ephemeral runoff and direct infiltration of precipitation recharges the main ground water system in this area. Subsurface inflow from the bedrock also recharges the regional ground water system in the foothills recharge area.

6.5.1.4 *Other Perched Ground Water*

Three additional areas of perched ground water have been identified at the Plant site.

P.E. LaMoreaux (PELA) identified an area of perched ground water underlying the northeastern portion of the Plant in the vicinity of the north impoundment and wastewater



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Approximate Boundaries of the Mapleton Bench & Foothills Recharge Area

FIGURE 6-14

dispersion area. This area is a small structural graben bounded by the Wasatch Fault to the east and a northeast-southwest trending antithetic fault to the west Approximately 5 feet of saturated sands and gravels were observed overlying an olive gray clay present at a depth of approximately 30 to 50 feet below grade. Water level elevations measured by ES (1990) indicated that perched ground water in this area flowed to the northeast toward the Wasatch Fault and alluvial deposits originating from Crowd Canyon. Cross-sections C-C' and E-E' are drawn through this former zone of perched ground water. The cross-sections illustrate that perched ground water flow would be restricted to the west by the presence of subsurface clays and there is connectivity with the Crowd Canyon alluvium to the north. When wastewater discharges to this area were terminated in 1991, water levels dropped below the base of the shallow B-series wells which were open to the perched ground water. Several soil borings performed during the ongoing RFI investigation in this area encountered some saturated deposits within this approximate depth range.

Soil borings and monitoring wells installed during the ongoing RFI have identified a deeper interval of perched ground water in the northeast portion of the Plant in the vicinity of the North Impoundment and Wastewater Dispersion Area. Eight monitoring wells that are open to this interval of perched ground water have been installed at total completion depths of approximately 82 to 105 feet below the ground surface in this area. Based on preliminary data collected from four new monitoring wells open to the regional unconsolidated aquifer in this area, this interval of perched ground water is approximately 75 to 105 feet higher than the top of the zone of saturation of regional unconsolidated aquifer. Additional information regarding perched ground water identified in this area is presented in Section 6.7.3 of this CAP.

A third zone of perched ground water was preliminarily identified in the northwest portion of the Plant during initial site investigation activities during the ongoing RFI. A soil boring advanced in SWMU 26, near the Mapleton Lateral encountered a 2.6 foot saturated zone at a depth of approximately 45 feet below the ground surface. An attempt to install a monitoring well open to perched ground water in this area was unsuccessful as no water was observed at the anticipated depth. Attempts to install monitoring wells open to perched ground water were also unsuccessful at locations south of SWMU 26. This information suggests that the perched ground water preliminarily identified in this area during the earlier soil boring program is either very localized, transient or both.

6.5.2 Water Balance

The sources and quantities of ground water recharge and discharge are important considerations for developing a conceptual model of the study area. The locations and relative magnitude of ground water recharge and discharge areas affect ground water flow and solute transport. Brooks and Stolp (1995) presented a detailed ground water budget for Southern Utah Valley for 1990. Their evaluation is the basis for the recharge and discharge estimates presented herein. It is recognized that the quantities of recharge and discharge in the study area vary through time, primarily as a direct result of varying amounts of precipitation. The 1990 data have been selected because they represent the most complete set of data available for the study area. While the overall quantity of recharge and discharge will change over time, the locations and relative magnitude of recharge and discharge from a given source or location are expected to remain relatively constant.

Based on the data provided by Brooks and Stolp (1995) for annual recharge estimates to the main ground water system in Southern Utah and Goshen Valleys from perennial streams and major canals, irrigation and precipitation and intermittent and ephemeral runoff from 1949 to 1990, the average total annual recharge from these sources is approximately 96,500 acre-ft per year. The 1990 recharge estimate for these same sources was approximately 63,000 acre-ft or about 65 percent of the estimated annual recharge. These estimates do not include subsurface inflow from bedrock.

Brooks and Stolp (1995) prepared a numerical ground water flow model for Southern Utah and Goshen Valleys using Modflow. These modeling files have been obtained from the Utah Division of Natural Resources. Recharge and discharge values for the study area were extracted from the calibrated model files for 1990.

6.5.2.1 Ground Water Recharge

According to Brooks and Stolp (1995) the main ground water system in Southern Utah Valley receives most recharge near the mountains where surficial materials are permeable enough to allow infiltration. Ground water recharge to the regional aquifer in the study area is from four primary sources:

1. Infiltration from perennial streams and major irrigation canals (Spanish Fork River, Hobble Creek and Maple Creek);
2. Direct infiltration of precipitation in the Mountain Front Recharge Zone;
3. Infiltration from intermittent and ephemeral runoff along the mountain front; and,
4. Subsurface inflow from the adjacent bedrock aquifer and the channel deposits of streams that enter the study area.

For 1990, Brooks and Stolp (1995) estimate that recharge to the main aquifer system in Southern Utah Valley from all the previously listed sources was approximately 120,000 acre-ft.

Brooks and Stolp assume that recharge does not occur to the regional ground water system in the study area from applied irrigation water, seepage from earthen irrigation canals (i.e. Fullmer Ditch, East Bench Canal, Mapleton Lateral) and precipitation west of the foothills recharge area due to the presence of the perched Mapleton Bench ground water system that prevents downward flow. Brooks and Stolp (1995) estimated total recharge to the Mapleton Bench ground water system in the study area to be approximately 9,600 acre-ft in 1990, including 7,900 acre-ft from applied irrigation water and direct infiltration of precipitation and 2,500 acre-ft from major irrigation canals. Approximately 3,900 acre-ft of this total is from within the study area. Brooks and Stolp

(1995, Table 2) assume there is no recharge to the Mapleton Bench ground water system from the Mapleton Lateral, which is the major irrigation canal within the study area.

6.5.2.1.1 Perennial Streams and Major Irrigation Canals

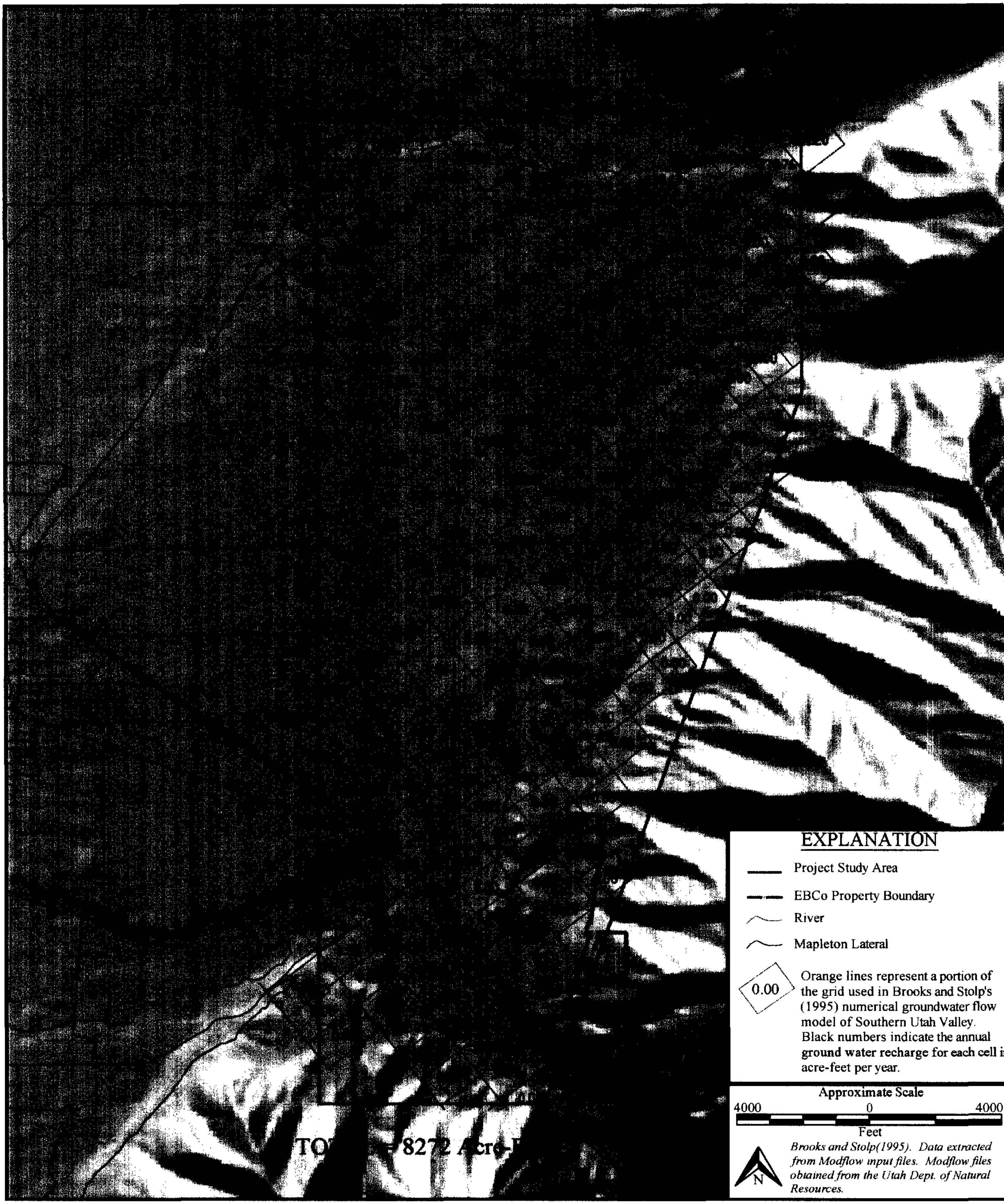
Brooks and Stolp (1995) estimate the 1990 recharge to the regional aquifer system from the Spanish Fork River to be 2,310-acre ft in the reach from the Power Canal Diversion to the Mapleton Lateral. Brooks and Stolp (1995) estimate the 1990 recharge to the regional aquifer system from Hobble Creek to be 2,130-acre ft in the reach between the USGS gauging station in Hobble Creek Canyon and the Mapleton Lateral. Brooks and Stolp considered 1990 recharge to the regional aquifer system from Maple Creek to be negligible. According to Brooks and Stolp (1995), the Mapleton No. 1 Ditch, located in the northeast portion of the study area and originating at the mouth of Hobble Creek Canyon contributed approximately 50 acre-ft of recharge to the main aquifer system in 1990. No other irrigation canals contribute recharge to the main aquifer system in the study area.

Figure 6-15 presents the distribution and quantity of 1990 recharge to the main aquifer system within the study area due to leakage from perennial streams and major canals. These data were extracted from the stream flow package of Brooks and Stolp's Modflow model files. The small rectangular grids on the figure are the model cells from the Modflow model. Recharge from these sources is limited to the Spanish Fork River and Hobble Creek. A total of 8,272 acre-ft of water was modeled as recharging the main aquifer system within the boundary of the study area. Approximately 3,997 acre-ft of recharge was from Hobble Creek and 4,275 acre-ft was from the Spanish Fork River. These values are higher that the estimates cited by Brooks and Stolp by about a factor of two. This is due at least in part to the fact that the stream reaches within the study area are longer than those cited in Brooks and Stolp (1995). These differences may also be attributed to increased recharge necessary to balance and calibrate the ground water flow model.

Based on Brooks and Stolp's (1995) Modflow modeling files, the Spanish Fork River and Hobble Creek contributed approximately 43% of the total quantity of recharge to the regional unconsolidated aquifer system in the study area during 1990.

6.5.2.1.2 Direct Infiltration of Precipitation and Irrigation Water

Due to the presence of the Mapleton Bench ground water system, recharge to the regional aquifer within the study area from direct infiltration of precipitation occurs in the area defined as the foothills recharge area, at other locations along the mountain front and near the mouth of Spanish Fork Canyon. Little or no irrigation water is presently applied to these areas, therefore only the direct infiltration of precipitation is applicable in this area. Brooks and Stolp (1995) assumed that ten percent of the precipitation on more permeable non-irrigated land near the mountains recharged the main ground water system. The



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Distribution and Estimated Quantity of Recharge to the Regional Ground Water Aquifer in the Study Area From Perennial Streams 1990

FIGURE 6-15

average annual precipitation as measured at the Spanish Fork Power House is 19.2 inches per year, therefore ten percent of that value is approximately 2 inches per year (0.17 ft/year). The region within the study area where precipitation would infiltrate the regional aquifer is approximately 2,275 acres, therefore the average annual recharge to the regional aquifer in the study area from the direct infiltration of precipitation is approximately 387 acre-ft per year.

In the Modflow model, Brooks and Stolp did not distinguish recharge to the regional aquifer from direct infiltration of irrigation and precipitation from that due to the infiltration of intermittent and ephemeral runoff.

6.5.2.1.3 Intermittent and Ephemeral Runoff

According to Brooks and Stolp (1995) most intermittent and ephemeral runoff enters the valley in the spring when evapotranspiration rates are low. The runoff crosses the relatively higher permeability alluvial fan deposits and no channels are evident downstream from the alluvial fans. Brooks and Stolp assume that approximately 90 percent of the runoff infiltrates and recharges the regional aquifer. This recharge occurs within the foothills recharge area and at other locations along the mountain front. For 1990, Brooks and Stolp (1995) estimate the total recharge to the regional aquifer from infiltration of intermittent and ephemeral runoff to be 850 acre-ft per year for the drainages between Hobble Creek and the Spanish Fork River, with approximately 23 percent of this recharge (160 acre-ft per year) originating in Crowd Canyon. Assuming that annual intermittent and ephemeral runoff varies similarly to natural flow in the Spanish Fork River at Castilla, Brooks and Stolp estimated the average annual recharge to the regional aquifer from infiltration of intermittent and ephemeral runoff to be 1,740 acre-ft per year for the drainages between Hobble Creek and the Spanish Fork River, with approximately 20 percent of this recharge (340 acre-ft per year) originating in Crowd Canyon.

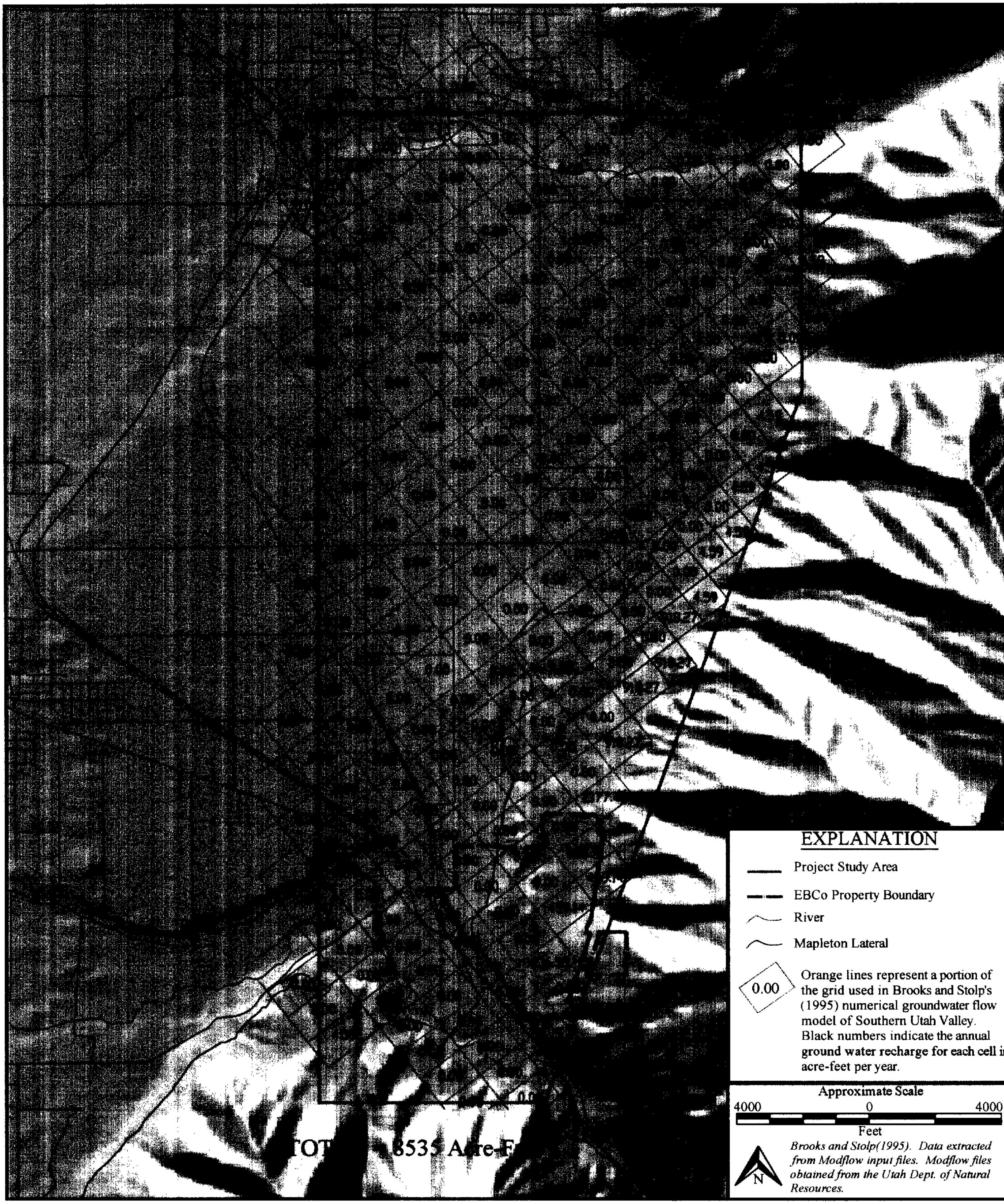
Figure 6-16 illustrates the distribution and quantity of recharge to the main regional aquifer in the study area for 1990 as modeled by Brooks and Stolp due to the combination of intermittent and ephemeral runoff, the direct infiltration of irrigation and precipitation and from selected perennial streams and major canals not included in the stream flow package. The total recharge to the regional aquifer for 1990 from these sources is approximately 2,346 acre-feet. The location along the eastern boundary of the study area with the highest volume of recharge is at the mouth of Crowd Canyon. Relatively higher amounts of recharge from these sources also occur in the area north of Hobble Creek near the canyon mouth. Brooks and Stolp (1995, Table 3) estimate the 1990 recharge to the regional aquifer system from intermittent and ephemeral runoff to be 850 acre-ft for the drainages between Hobble Creek and the Spanish Fork River. As noted earlier, the average annual volume of recharge to the regional unconsolidated aquifer in the study area due to direct infiltration of precipitation is estimated to be 387 acre-feet per year. The sum of these two recharge estimates is 1,247 acre-ft per year. This value is in close agreement with the sum of the recharge estimates shown on Figure 6-16 for the area along the eastern margin of the study area between Hobble Creek and the Spanish Fork River and those areas where Brooks and Stolp presumably show recharge due to the direct infiltration of precipitation (approximately 1,215 acre-ft per year).

According to Brooks and Stolp's (1995) Modflow modeling files, intermittent and ephemeral runoff and the direct infiltration of precipitation and applied irrigation water contributed approximately 12% of the total volume of recharge to the regional unconsolidated aquifer in the study area during 1990.

6.5.2.1.4 Subsurface Inflow

Subsurface inflow to the regional aquifer is from consolidated bedrock and from underflow in the unconsolidated stream-channel deposits. According to Brooks and Stolp, the flow in the stream-channel deposits is probably small because these deposits are relatively narrow and thin when compared with the interface between the bedrock aquifer and the unconsolidated basin-fill deposits. Brooks and Stolp were not able to directly calculate the quantity of subsurface inflow and instead calculated this value as the amount of inflow needed to calibrate the ground water flow model. This method of estimation incorporates the potential inaccuracies in all other flow budget estimates and therefore there may be error in the estimate for subsurface inflow. A total of approximately 8,535 acre-ft of recharge to the regional aquifer from subsurface inflow was estimated for the study area in 1990. This estimate was derived from the boundary conditions established for the calibrated USGS ground water flow model for Southern Utah Valley. This volume of subsurface inflow compares favorably with the estimated annual recharge of 6,226 acre-feet to the bedrock aquifer underlying Spanish Fork Peak calculated based on snow water equivalent and precipitation data from numerous monitoring stations throughout the Wasatch Mountains (Owens Western, 1995a). Additionally, Mifflin (1988) notes that most of Utah, including the study area, is located in the carbonate rock province of the Great Basin. According to Mifflin, in areas underlain by thick sequences of Paleozoic limestone (such as the Oquirrh Formation), ground water flow paths are not necessarily concordant with the hydrographic and structural basins and there is likely to be extensive circulation of ground water between some structural basins. Therefore, bedrock recharge to the study area may originate from areas outside of the hydrologic basin.

The distribution of subsurface inflow into the study area as modeled by Brooks and Stolp (1995) is illustrated in Figure 6-17. While the volume of subsurface inflow at a given location may vary in response to changes in precipitation, the relative magnitude of the recharge at these different locations is expected to remain relatively constant. Of interest is the substantially higher volume of subsurface inflow along the mountain front in the southeastern portion of the study area as compared to the northeastern two-thirds of the study area where relatively little subsurface inflow was modeled by Brooks and Stolp. The highest volumes of recharge from subsurface inflow were modeled in the area of the Plant site (1,837 acre-ft) and at the mouth of Crowd Canyon (1,377 acre-ft).



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Distribution and Estimated Quantity of Recharge to the Regional Ground Water Aquifer in the Study Area From Subsurface Inflow
1990

FIGURE 6-17

According to Brooks and Stolp's (1995) Modflow modeling files, subsurface inflow contributed approximately 45% of the total volume of recharge to the regional unconsolidated aquifer in the study area during 1990.

6.5.2.2 Ground Water Discharge

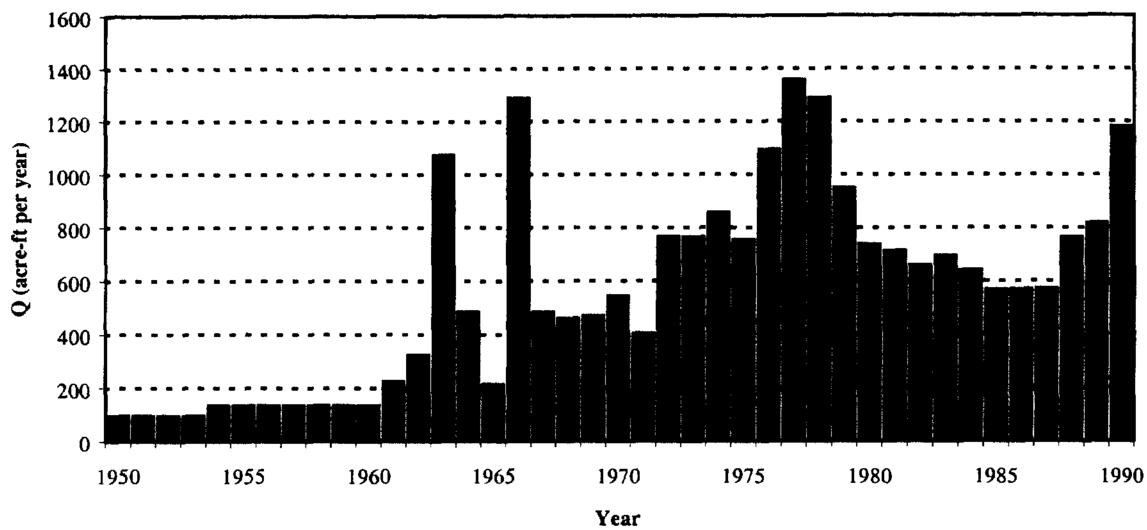
Discharge from the regional aquifer system in Southern Utah valley is to springs, drains, flowing wells, pumping wells, streams, canals, infiltration into sewer systems and by seepage to Utah Lake. In 1990, the total discharge from the regional aquifer system in Southern Utah valley was estimated by Brooks and Stolp (1995) to be approximately 130,000 acre-ft. Within the study area, the regional aquifer system does not discharge to springs, streams, lakes and flowing wells and is not subject to losses due to evapotranspiration. All discharges to these receptors are in areas west of the study area. The only discharge from the regional aquifer system in the study area is from pumped wells.

There are a total of approximately 66 production wells that tap the regional aquifer system in the study area. Six of these wells are high capacity municipal water and/or irrigation supply wells capable of producing between approximately 750 to 1,500 gpm. The remaining wells are privately owned, of lower capacity (assumed to be approximately 20 to 50 gpm) and are used for domestic, irrigation and stockwatering applications. Well use is typically highest during the irrigation season from April through October when municipal and irrigation demands are the highest. Municipal demands have also increased through time as municipal services have expanded to meet the water needs associated with area growth

Based on the well package from Brooks and Stolp's model files, the estimated total ground water withdrawal from wells within the study area in 1990 was approximately 1,185 acre ft. This is equivalent to an annual average constant discharge rate of 750 gpm. This number underestimates the total ground water withdrawal by pumped wells in the study area because Brooks and Stolp only included those wells capable of pumping more than 30 gpm in the USGS ground water flow model simulation. It is likely that discharge from pumping wells in the study area has increased since 1990 due to the expansion of the municipal water system in Mapleton with population growth. Few small domestic wells have been installed in the study area since 1990 so the majority of the suspected increase is due to high volume municipal wells.

Figure 6-18 is a bar chart illustrating the discharge from pumping wells within the study area from 1950 to 1990. These data were extracted from the well package of Brooks and Stolp's modeling files. Pumping increased markedly in the 1960's due to the installation of several high volume irrigation wells in response to a period of extended drought. Pumping increased steadily in the 1970's probably due to increased municipal demands. The decline in pumping during the mid-1980's may reflect the above normal precipitation caused by the El Nino which would have reduced irrigation needs and produced higher amounts of flow in municipal spring sources.

Figure 6-18: Pumping Well Discharge Within Study Area 1950 - 1990



According to Brooks and Stolp (1995), in 1990, the Mapleton Bench ground water system discharged approximately 3,500 acre-feet of water to springs and 10,900 acre-ft of water to Hobble Creek and the Mill Race Canal.

6.6 Site-Specific Hydrogeologic Data

The following section presents a summary of site-specific hydrogeologic data collected over the course of the hydrogeologic investigation. Aquifer parameter data provide information about the hydraulic characteristics of the subsurface materials including transmissivity and storage characteristics. Water level elevation data are useful for approximating the top of the zone of saturation of the regional aquifer and for qualitatively evaluating directions of ground water flow in the study area. General water chemistry data provides information about the similarity or dissimilarity of ground water throughout the study area.

6.6.1 Aquifer Parameters

6.6.1.1 Transmissivity and Storativity

According the Fetter (1980):

Transmissivity (T) is the measure of the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer under a unit hydraulic gradient.

T is equal to the product of the hydraulic conductivity (K) and the saturated thickness (b). Transmissivity has dimensions of ft^2/day.

Hydraulic Conductivity (K) is a measure of the amount of water that can move through a unit area under a unit gradient in a porous medium. Hydraulic conductivity has dimensions of ft/day. Transmissivity divided by aquifer thickness equals hydraulic conductivity.

Storativity (S), or storage coefficient, is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of the specific storage and aquifer thickness. In an unconfined aquifer the storativity is equal to the specific yield. Storativity is a dimensionless quantity. The value of storativity for confined aquifers is on the order of 0.005 or less. The storativity of unconfined aquifers ranges from approximately 0.02 to 0.30.

Specific Storage (S_s) is the amount of water per unit volume of saturated formation that is stored or expelled from storage due to the compressibility of both the mineral skeleton and pore water. Specific storage has dimensions of 1/L and generally has a small value of 0.000003/ft or less.

Specific Yield is the ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of rock or soil.

Transmissivity estimates have been made based on information contained in drillers reports (flow rates and drawdowns) and using the Verigin Reduction Method (Brown, 1972). Both ES (1989, 1990) and Owens Western (1993, 1995) utilized the Verigin method to derive estimates of transmissivity. Long-term multi-observation well pump tests were performed upon completion of the three recovery wells (R-1, R-2 and R-3). These results were presented in Owens Western (1997) and Charter Oak (1998). Cordova (1970) provided estimates of transmissivity and storativity based on a multiple well, and long-term pumping test of wells in the study area. All of the reported transmissivity estimates are from wells that partially penetrate the regional aquifer. Transmissivity and storativity estimates for selected wells in the study area are listed in Table 6-2.

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Table 6-2: Estimated Aquifer Parameters for Regional Unconsolidated Aquifer

Well ID	Estimated T (ft^2/day)	Estimated Storativity	Reference
FW-2	200		Charter Oak, 1999
R-2	230		Charter Oak, 1998
R-3	240	0.001	Owens Western, 1998
R-1	2,930	0.0001	Charter Oak, 1998
Orton-23	9,660		Charter Oak, 1998
FW-1	15,200		Charter Oak, 1999
Westwood	22,000	0.00002	Owens Western, 1995
Olsen	29,000	0.0005	Brooks & Stolp, 1995
Orton-14	67,000	0.004	Cordova, 1970
Mapleton No. 1	71,000	0.0005	Brooks & Stolp, 1995
Hjorth	73,700	0.0005	Cordova, 1970
Seal	93,800	0.0005	Cordova, 1970

The aquifer parameters summarized in Table 6-2 are used to generally characterize the hydraulic characteristics of the unconsolidated regional aquifer.

Relatively fine grained unconsolidated deposits, primarily consisting of fine sands, silty sands and gravel mixtures occur in the regional aquifer, underlying the elevated topographic bench in the southeastern portion of the study area. Transmissivity estimates for deposits in this area vary over an order of magnitude and range from about 200 to 3,000 ft^2/day, based on available data.

The thick sequence of coarse alluvium in the regional aquifer associated with the Spanish Fork River stream channel and delta have transmissivity estimates of about 15,000 ft^2/day.

The thick sequence of coarse alluvium in the regional aquifer associated with the Hobble Creek stream channel and delta has an estimated transmissivity of up to 93,800 ft^2/day. The unconsolidated deposits in the regional aquifer underlying the Mapleton Bench have transmissivity estimates ranging from approximately 9,700 to 73,700 ft^2/day.

No site-specific hydraulic information is available for the perched surficial aquifer in the Mapleton Bench area. These unconsolidated deposits consist primarily of sands, gravels, silty sands and silty sand and gravel mixtures.

6.6.1.2 Porosity

Porosity (n) is defined as the percentage of rock or soil that is void of material (Fetter, 1980). The total porosity of unconsolidated granular deposits is commonly in the range of 20 to 40 percent (Freeze and Cherry, 1979). Typical ranges of total porosity for various aquifer materials have been compiled from a number of sources and are summarized Table 6-3.

Table 6-3: Typical Ranges of Total Porosity for Aquifer Materials

Aquifer Material	Total Porosity (%)
Clayey	40 - 60
Silty	35 - 50
Sandy	20 -50
Gravelly	25 - 40

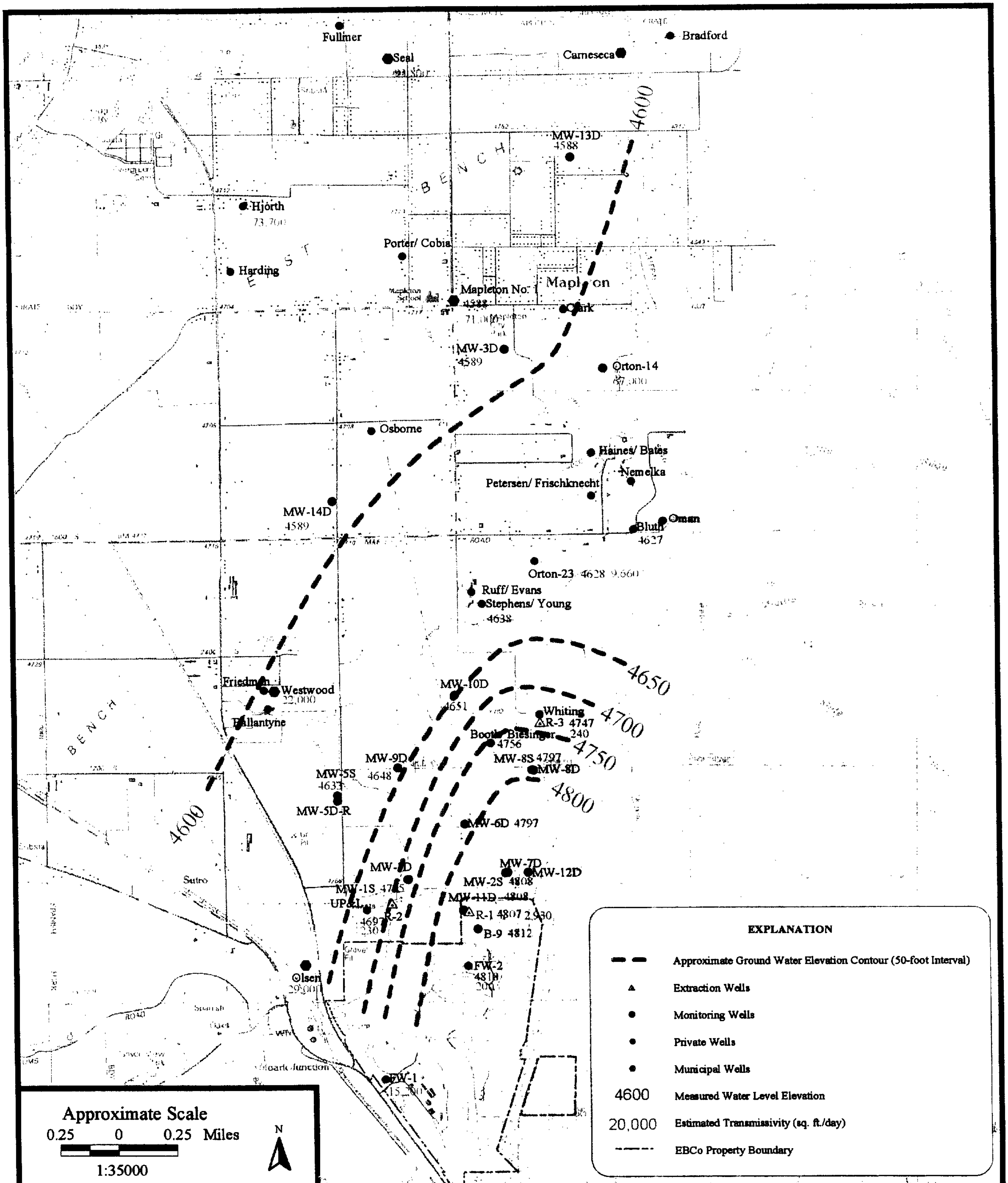
6.6.2 Water Level Data

6.6.2.1 Distribution of Area Water Level Elevations

Water levels are measured in both monitoring wells and private wells that are open to the regional aquifer system. The number of monitoring locations has expanded in recent years because of new monitoring well construction or by gaining access to privately owned wells for water level measurements.

Figure 6-19 shows the approximate ground water level contour map of the regional aquifer. This map is an approximation of the top of the zone of saturation of the regional aquifer. Water level elevations were measured on January 20, 2000 with the exception of MW-5S and MW-5D (measured on January 4, 2000) and MW-9D (measured in October 1999). The January data set was selected for a number or reasons: 1) The data set was nearly complete for study area observation wells; 2) The recovery system had not been running since November 19, 1999; and, 3) Well use in the study area is at a minimum during the winter months when no irrigation is necessary.

The following factors were considered in preparation of the contour map. A downward component of ground water flow occurs in the foothills recharge area. Because of this, water levels from shallower wells provide a better approximation of the water table in this area. An exception is noted in wells located near the mouth of Crowd Canyon (MW-2S and MW-7D) and in the northeast corner of the Plant (B-9, MW-11D, FW-2 and R-1). The intake depths for these wells vary considerably, yet the water levels are nearly the same. This may reflect nearly horizontal flow due to subsurface inflow from the consolidated bedrock in this area. In accordance with Mifflin (1968) ground water flow underlying the Mapleton Bench area is inferred to be either horizontal or approaching horizontal. Water levels from wells completed at variable depths should have



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Approximate Ground Water Level Contour Map of the Regional Ground Water Aquifer
January 2000

FIGURE 6-19

comparable water levels within this region. Water level data recorded by well drillers were examined for several wells completed in the regional unconsolidated aquifer at different depths. Because water levels were measured during different seasons and years, a direct comparison of water level information from wells completed at different depths is not possible. However, the average difference in water levels measured from selected wells that are in relatively close proximity to one another and completed at different depths (i.e. Osborne and MW-14D) is approximately eleven feet. This is substantially less than the average difference in water levels at the MW-1S/MW-1D and MW-5S/MW-5D well pairs which are approximately seventy-one and thirty-six feet, respectively. These well pairs are within the foothills recharge area and do not underlie the Mapleton Bench, so vertical downward ground water flow is expected at these locations. Based on the forgoing evaluation, a horizontal flow assumption is probably reasonable for ground water flow in the regional aquifer below the Mapleton Bench. Because of uncertainty about the actual water table elevation across the study area a contour interval of 50-feet was selected.

Because of the heterogeneous nature of the regional aquifer and the variable well completion depths, it is not appropriate to estimate the direction of ground water movement by showing flow lines perpendicular to the ground water level elevation contours. Nevertheless, Figure 6-19, which approximates the top of the zone of saturation, can be used to qualitatively assess the general direction of ground water flow in the regional aquifer system.

The configuration of the approximate ground water level contours of the regional aquifer in Figure 6-19 is consistent with having relatively more recharge flow into the unconsolidated basin fill deposits in the northern part of the EBCo property than occurs on other parts of the foothills recharge area in the study area. The ground water level contours are consistent with Mifflin's (1968) idealized cross section of flow in basins (see Figure 6-12) where the top of the saturated zone (water table) tends to steepen at the margin of the basin as a result of recharge and tends to flatten toward the central part of the valley where little, if any, recharge occurs. In addition, lateral variations in the permeability of the basin fill deposits from relatively lower permeability in the foothills recharge area to relatively higher permeability beneath the Mapleton Bench also can contribute to the configuration of the ground water level contours. Transmissivity estimates from selected wells are shown in Figure 6-19.

Even though ground water flow lines or streamlines cannot be scientifically constructed, as discussed above, the shape of the contour map, which shows ground water flowing downhill, can be used to interpret the general direction of ground water flow. In the northern part of the EBCo property and just beyond, ground water levels show very little variation with depth, and the shape of the contour map in this area can be described as a water table bench. Ground water flows from this bench area in all directions from west to the northeast into the unconsolidated basin fill deposits.

6.6.2.2 Hydrographs

Figure 6-20, presents hydrographs for selected monitoring wells and privately owned wells where water level data are available. Recovery wells are not included as they are addressed in Section 11 of this CAP. The horizontal axis (X) of each hydrograph represents time and runs from January 1991 through January 2002. The vertical axis (Y) is the water level elevation and covers a range of sixty-feet in each hydrograph. The upper and lower values of the water level elevation range may vary between hydrographs.

These hydrographs illustrate a substantial rise in water levels in wells located along the eastern margin of the study area and within or adjacent to the foothills recharge area. This increase in water levels is coincident with the above average precipitation from 1994 to 1998 after a period of average or below average precipitation from 1987 through 1993. Water levels in this area, particularly within the Crowd Canyon alluvium rose over fifty feet over this four-year period. Water levels in MW-8D only rose about twenty feet, perhaps reflecting relatively less recharge to the materials in which MW-8D is set. Water levels rose approximately thirty feet in MW-9D and MW-10D, which are open to the deep regional aquifer underlying the Mapleton Bench and are close to the foothills recharge area. Water levels in wells further to the west (MW-5S, MW-5D and MW-3D) rose only ten to twenty feet during the 1994 to 1998 time period.

Water levels in all wells have declined since 1999. This decline probably reflects lower recharge due to below average precipitation, as well as an overall decline in water levels due to the nearly continuous operation of the ground water recovery system and the extensive pumping of other high volume municipal wells (Seal, Carneseca) over the last three years. The fluctuations in water levels during 2000 and 2001 in MW-14D, MW-5D, MW-3D, MW-13D and MW-5S probably reflect the seasonal pumping of high volume municipal wells. Seasonal pumping effects are also observed in MW-3D, MW-5S and MW-5D between 1991 and 1993. Seasonal effects are less obvious between 1994 and 1998 and probably reflect the fact that the Mapleton No. 1 well was not used, the Westwood well was used only sparingly and the municipal springs had high flows as a function of the increased precipitation. Some of the more rapid water level changes observed in certain wells since 1998 reflect the stopping and starting of nearby extraction wells.

Water levels in MW-12, which is open to the bedrock aquifer, exhibit a nearly steady declining trend since 1999. Water levels in the bedrock aquifer are not expected to be affected by pumping, so this decline most likely reflects the below average precipitation.

6.6.3 General Water Chemistry

As water flows through an aquifer it assumes a diagnostic chemical composition resulting from interaction with the porous media through which it flows. Bodies of ground water within an aquifer that possess differing chemical compositions are called hydrochemical facies and are a function of the lithology, solution kinetics and ground water flow patterns. If a recharge source (i.e. an industrial discharge that recharges the ground water aquifer or recharge from a surface stream) has a unique chemical signature, it may be possible identify that distinctive chemistry in the ground water system.

The most common general water chemistry parameters include the anions Chloride (Cl^-), Sulfate ($SO_4^=$), carbonate ($CO_3^=$) and bicarbonate ($HCO_3^=$) and the cations Sodium (Na^+), Potassium (K^+), Calcium (Ca^{++}) and Magnesium (Mg^{++}). Typically concentrations of these parameters are converted from concentrations expressed in mg/L to concentrations expressed in milliequivalents per liter (meq/L). The most common way to evaluate these data is through the use of trilinear diagrams (Piper diagrams) or Stiff diagrams.

General water chemistry data have been collected from wells periodically during the hydrogeologic investigation. These general water chemistry data were provided in the Phase IA (Dames and Moore, 1992) and Phase IB (Owens Western, 1993) hydrogeologic investigation reports and the Third Quarter 2000 Quarterly Report (Charter Oak, 2001). Additionally, in 1990 water from the North Impoundment was sampled and analyzed for general water chemistry parameters. DWQ also periodically collects general water chemistry data from the Spanish Fork River at the Moark Diversion. Data from four 1999 sampling events of the Spanish Fork River (8/99, 9/99, 10/99 and 11/99) were downloaded from the EPA Storet database and are included on the Piper diagram. These general water chemistry data from the Spanish Fork River appear to differ depending on when the sample was collected. It appears that during the irrigation season (8/99 and 9/99 samples) the water transferred into the river from the Strawberry Reservoir has a different chemical signature than the water that flows in the river naturally during the non-irrigation season (10/99 and 11/99 samples). These Spanish Fork River data are presented on the Piper and Stiff Diagrams in three ways: 1) the average of the four samples; 2) the average of the irrigation season samples; and, 3) the average of the non-irrigation season samples.

Figure 6-21 is a Piper diagram presenting general water chemistry data from the third quarter 2000 sampling event. General water chemistry data from the 1990 sampling of the North Impoundment is also included for comparison with area ground water as are data from the Spanish Fork River. These data indicate that the ground water in the study area is predominantly of the calcium bicarbonate type. No uniform distinctions can be made between ground water found in differing hydrostratigraphic units so it is appropriate to consider the ground water to be a single hydrochemical facies. It is interesting that the general water quality characteristics of FW-1, Olsen and Westwood are grouped together having relatively more sulfate, chloride, sodium and potassium than most other wells. These three wells plot close to the annual average and non-irrigation season average for the Spanish Fork River, suggesting this may be related to the influence of ground water recharge from the Spanish Fork River. Water from the North Impoundment has a distinct chemical signature and is a mixture of sodium chloride, sodium bicarbonate and sodium sulfate types.

Figure 6-22 presents Stiff diagrams for each individual well sample from the third quarter 2000, the 1990 North Impoundment Sample and the annual, irrigation season and non-

Figure 6-21: Piper Diagram of General Water Chemistry Data

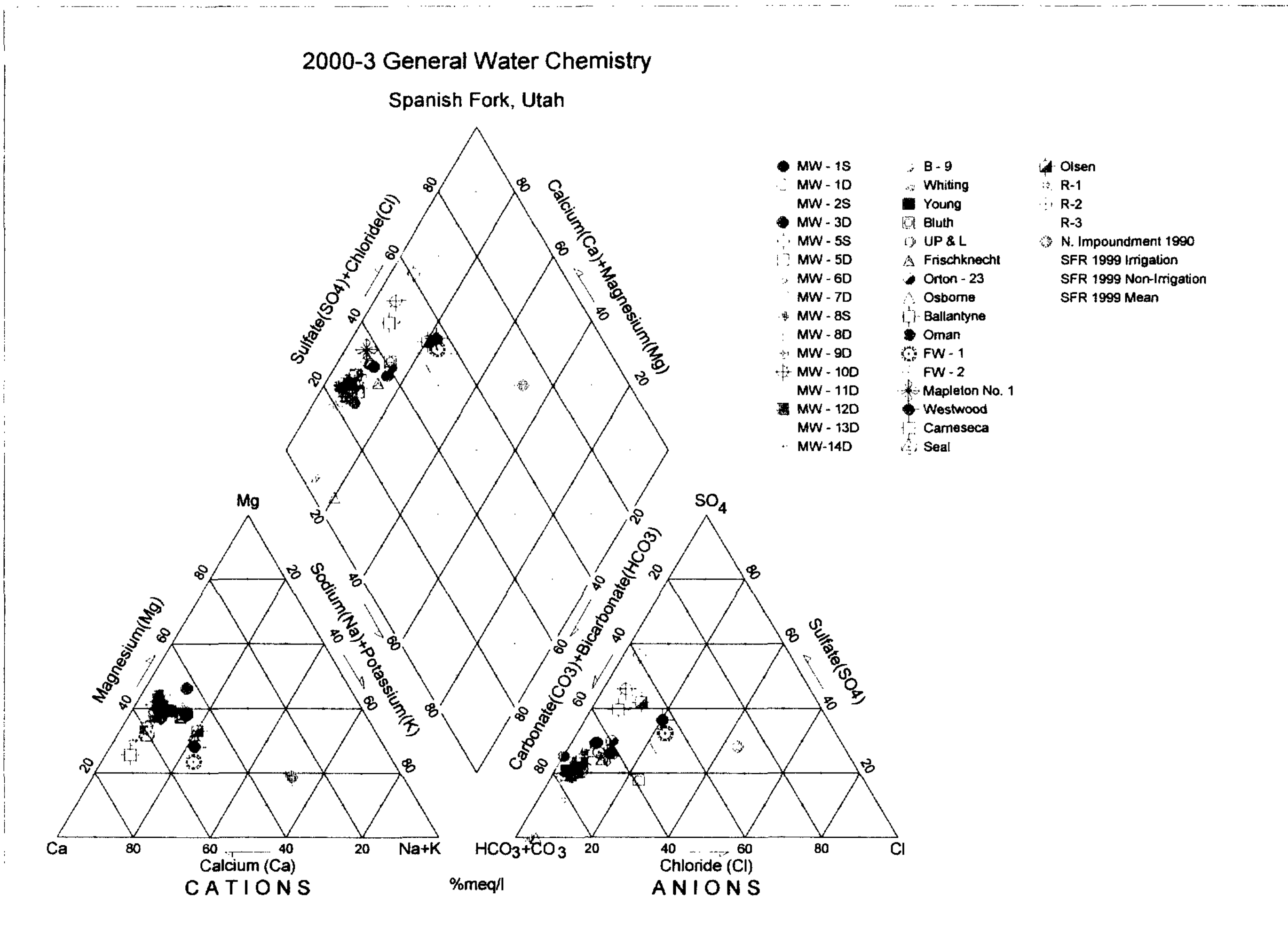
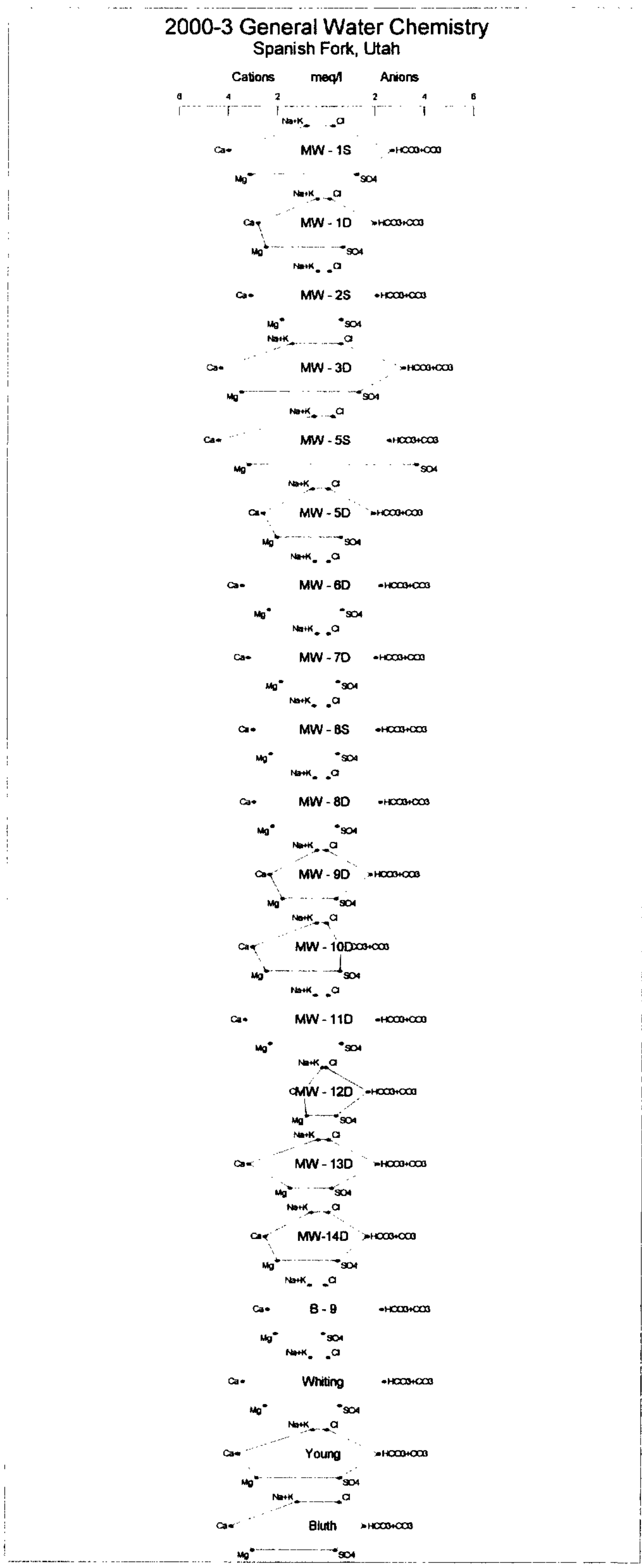
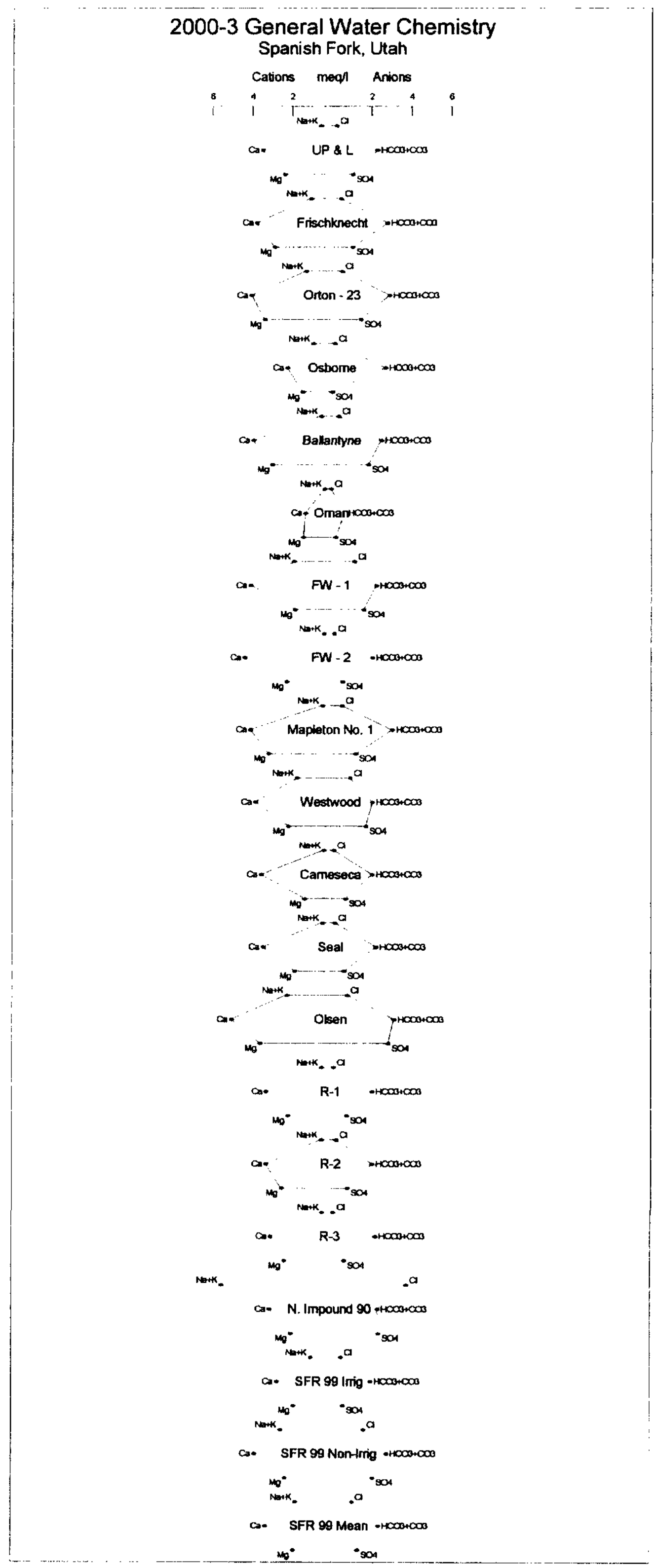


Figure 6-22: Stiff Diagrams of General Water Chemistry Data





irrigation season averages for the Spanish Fork River. The shapes of the polygons created by each Stiff diagram provide a quick comparative visual tool for assessment of water chemistry characteristics. The two samples collected from the bedrock aquifer have distinctive signatures both in overall size of the polygon and to a lesser degree the shape. The smaller size is indicative of the lower overall ionic strength of the water in the bedrock aquifer as compared to the unconsolidated regional aquifer. These two wells also indicate that water in the bedrock aquifer has somewhat less meq/L of calcium and relatively more magnesium as compared to the unconsolidated regional aquifer. These plots also show the relatively higher amounts of sulfate at MW-5S, Olsen, FW-1, Westwood and Ballantyne. Relatively higher amounts of chloride are also observed at FW-1, Olsen and Westwood. The Stiff diagrams of annual average and non-irrigation season average data from the Spanish Fork River also indicate relatively higher amounts of sodium, sulfate and chloride. The chemical signature for the North Impoundment water is distinct with significantly higher concentrations of chloride and sodium as compared to ground water samples. Wells closest to the North Impoundment which are open to saturated deposits that probably were the most direct receptors for this discharge (MW-2S, MW-7D) do not have chemical signatures that indicate the influence of the North Impoundment. No such trends were observed in general water chemistry data collected in 1992, either. This finding would suggest that the volume of water that seeped into the regional aquifer from the North Impoundment is relatively small when compared with the volume of water naturally recharging the regional aquifer system.

6.6.4 Temperature and pH

Temperature and pH data are collected during each quarterly sampling event. The average temperature in the regional aquifer ranges between approximately 11.4°C (52.5°F) and 17°C (62.6°F). Ground water temperatures in the deeper portions of the regional aquifer are an average of 2.3°C (4.1°F) warmer than shallower wells and wells located within the mountain front recharge zone. Ground water temperatures vary seasonally over a range of approximately 2°C (3.6°F) to 4°C (7.2°F). Average ground water pH values for the regional aquifer fall with in a tight range from approximately 7.3 to 7.7 standard units. Seasonal trends are not observed in ground water pH data.

6.7 Potential Constituent Sources and Review of Preliminary RFI Data

This CAP addresses impacts to the regional unconsolidated aquifer from nitrate-nitrogen and CEMs. Potential source areas that may have acted or may continue to act as possible sources of solutes to ground water are identified herein. Preliminary soil and ground water quality data collected during the RFI have been considered when developing the constituent of concern list presented in Section 6.8.

6.7.1 Suspected Point Sources of Ground Water Impacts

There are no known discharges to the land surface at the Plant at this time. Discharges ceased in 1991 when EBCo completed the installation of a wastewater treatment facility. Discharges from the wastewater treatment system are directed to the Spanish Fork sanitary sewer system.

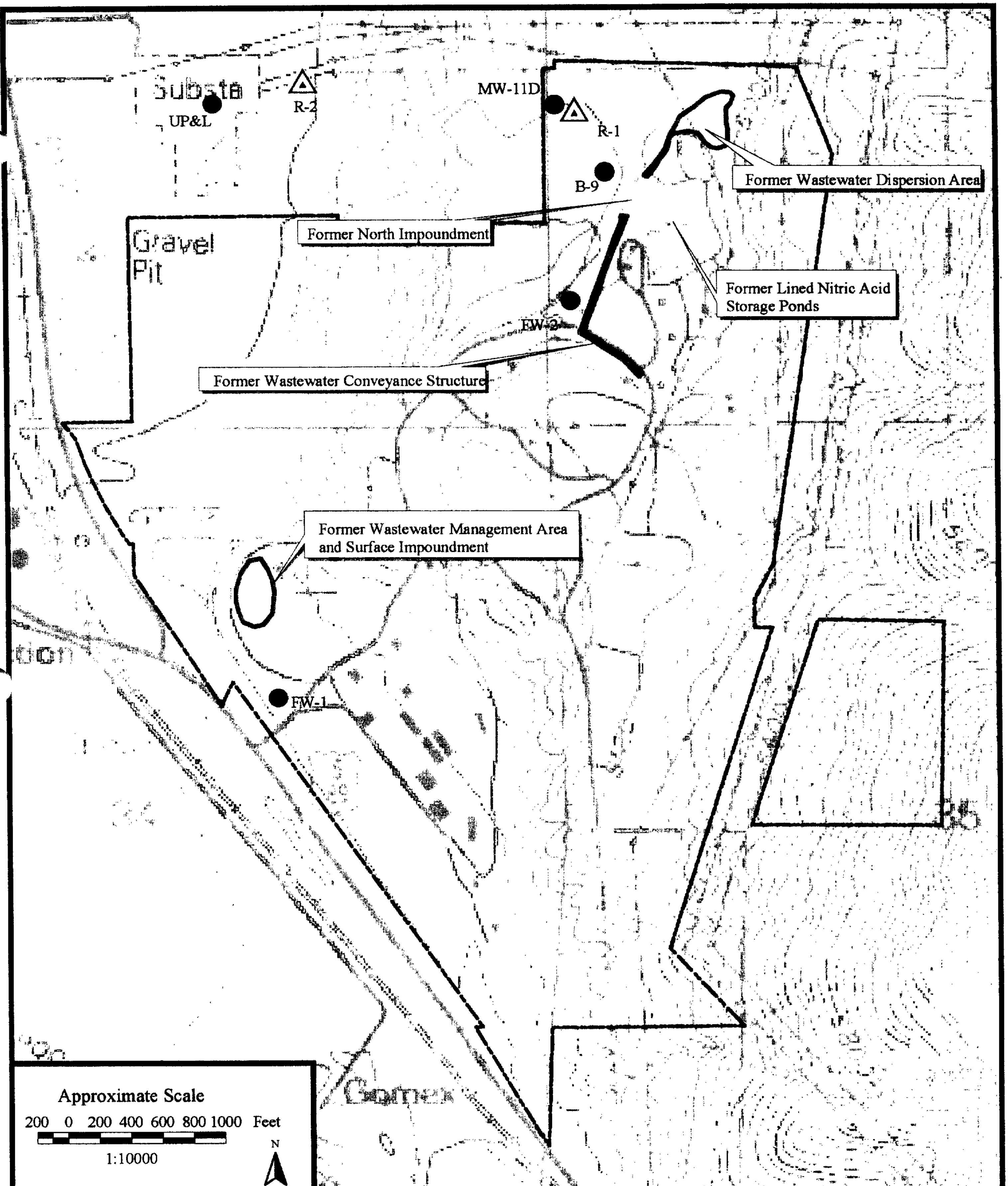
It is generally accepted by consultants working on this project and DWQ that the most likely sources of ground water impacts were the historic aqueous discharges and releases (as opposed to remaining residual impacts). Production-related discharges were primarily managed in two locations. Figure 6-23 presents the general outlines of these wastewater management areas.

1. The wastewater conveyance channel, north impoundment and wastewater dispersion area (SWMU 1) are located in the northeast portion of the Plant. These unlined, earthen structures received discharges from nitroglycerin production, PETN formulation, specialty nitrates formulation, RDX processing and HMX processing. The dilute nitric acid surface impoundments, used to store dilute nitric acid from PETN formulation (SWMU 3) are also present in this area. Discharges from production operations were directed to sumps (baffle tanks) to remove solid product from the wastewater discharge prior to release to the conveyance channel. Other SWMU's related to historic manufacturing operations are also located in this general area.

2. Liquids from nitroglycerin and nitrostarch production were also managed in the northwest portion of the Plant in what is identified as SWMU 26. Discharges from nitrostarch operations were directed to the ground surface in this unit. Aerial photographs indicate that a small, unlined surface impoundment was present in 1966 to contain these nitrostarch-related discharges. Discharges were run through a series of wooden settling tanks to remove solid product prior to discharge to the land surface. Aerial photos from 1952 and 1958 indicate that there were also releases to this unit from acid handling during nitroglycerin production.

6.7.2 Potential Off-Site Sources of Constituents of Concern

There are no known potential off-site sources for the CEMs. Dames and Moore (1992) performed a detailed review of potential off-site sources of nitrate-nitrogen. They identified and mapped numerous potential off-site sources of nitrate-nitrogen including septic fields, animal feed lots, stock yards, dairy farms, agricultural land, golf courses and natural nitrate deposits. Dames and Moore also noted the presence of high nitrate concentrations in ground water in other locations in Utah County having similar historic agricultural use and development. It has been generally acknowledged by the DWQ that alternative sources of nitrate are present in the study area and that these sources probably have contributed an unknown portion of the total nitrate-nitrogen concentrations found in



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Former Wastewater Management Areas at the EBCo Site

FIGURE 6-23

off-site ground water. Two wells open to the perched Mapleton Bench ground water system, (Johnson and Crandall) sampled by ES in 1989 contained 5.5 mg/L and 22 mg/L nitrate-nitrogen, respectively. Based on our understanding of the hydrogeologic system, these wells, which are open to the perched Mapleton Bench ground water system, are above the regional aquifer and could not have been impacted by releases from the Plant. As described in Section 6.7.3, solutes most likely entered the regional aquifer in the northeast and northwest portions of the Plant site in the areas of SWMU's 1 and 26. The perched Mapleton Bench ground water system is not present at these locations.

6.7.3 On-site RFI Investigation

Charter Oak is presently managing an extensive RFI at the EBCo site with participation by Montgomery Watson Harza and under the oversight of DSHW. Hundreds of soil samples, as well as surface and ground water samples have been collected from 44 SWMUs and analyzed for potential constituents of concern including CEMs, nitrates, metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). The RFI has not been completed but sufficient data has been generated to identify areas of on-site soil impacts and to preliminarily assess ground water quality in monitoring wells that have been installed on-site during the RFI. An in-depth review of the RFI information is beyond the scope of this CAP. RFI-related reports and documents prepared by Montgomery Watson are available at DSHW for review.

6.7.3.1 Perched Ground Water

Of particular interest to this CAP is information collected during the RFI pertaining to an area of perched ground water identified in the northeast corner of the EBCo site in the general vicinity of SWMUs 1 and 30. At the present time, the investigation of this area of perched ground water is not completed and additional investigation and data collection is ongoing. The ensuing discussion is based on preliminary data collected through the end of calendar year 2001. A thorough evaluation of the perched ground water system and its relationship to the underlying regional unconsolidated aquifer system will be presented in the RFI Summary Report. Nevertheless, sufficient information is available to qualitatively assess the perched ground water system and possible effects it may have on the underlying regional unconsolidated aquifer. Additional on-site data collection and evaluation will be necessary to confirm or revise the current observations.

The available information, discussed in greater detail below, provides for a conceptual understanding of perched ground water in this area. Perched ground water is present in unconsolidated deposits comprised of interbedded clays, silts, sands and gravels, with finer grained and lower permeability materials predominant in this area. Numerous fine grained silt and clay layers are present throughout the subsurface in this area and faulting probably adds an additional level of complexity to the subsurface stratigraphy. The perched ground water in this area is of limited aerial extent and thickness, indicating that the volume of perched ground water is very small when compared with the volume of ground water contained in the underlying regional unconsolidated aquifer. Lithologic information and observations made during drilling demonstrate that a substantial thickness of unsaturated materials separates this perched ground water from the underlying regional aquifer. Soil and water quality data from soil borings and monitoring wells in this area indicate that direct vertical downward movement of perched water to the underlying regional aquifer is unlikely.

Earlier investigations have demonstrated that shallow perched ground water historically present in this area flowed to the northeast and probably entered the regional aquifer though coarse grained alluvial deposits at the mouth of Crowd Canyon. The volume of this shallow perched ground water declined after wastewater management activities in this area were discontinued indicating that wastewater was probably the most prominent source of recharge to this shallow perched ground water. Based on this observation and other available information, the lateral flow of perched ground water and subsequent downward movement through coarse grained materials was a probable migration pathway for solutes to enter the regional aquifer in this area during the period when production wastewaters were discharged to the ground. Other than providing possible insight into past behavior of perched ground water and solute migration in this area, this shallow perched ground water is not of ongoing interest to the CAP.

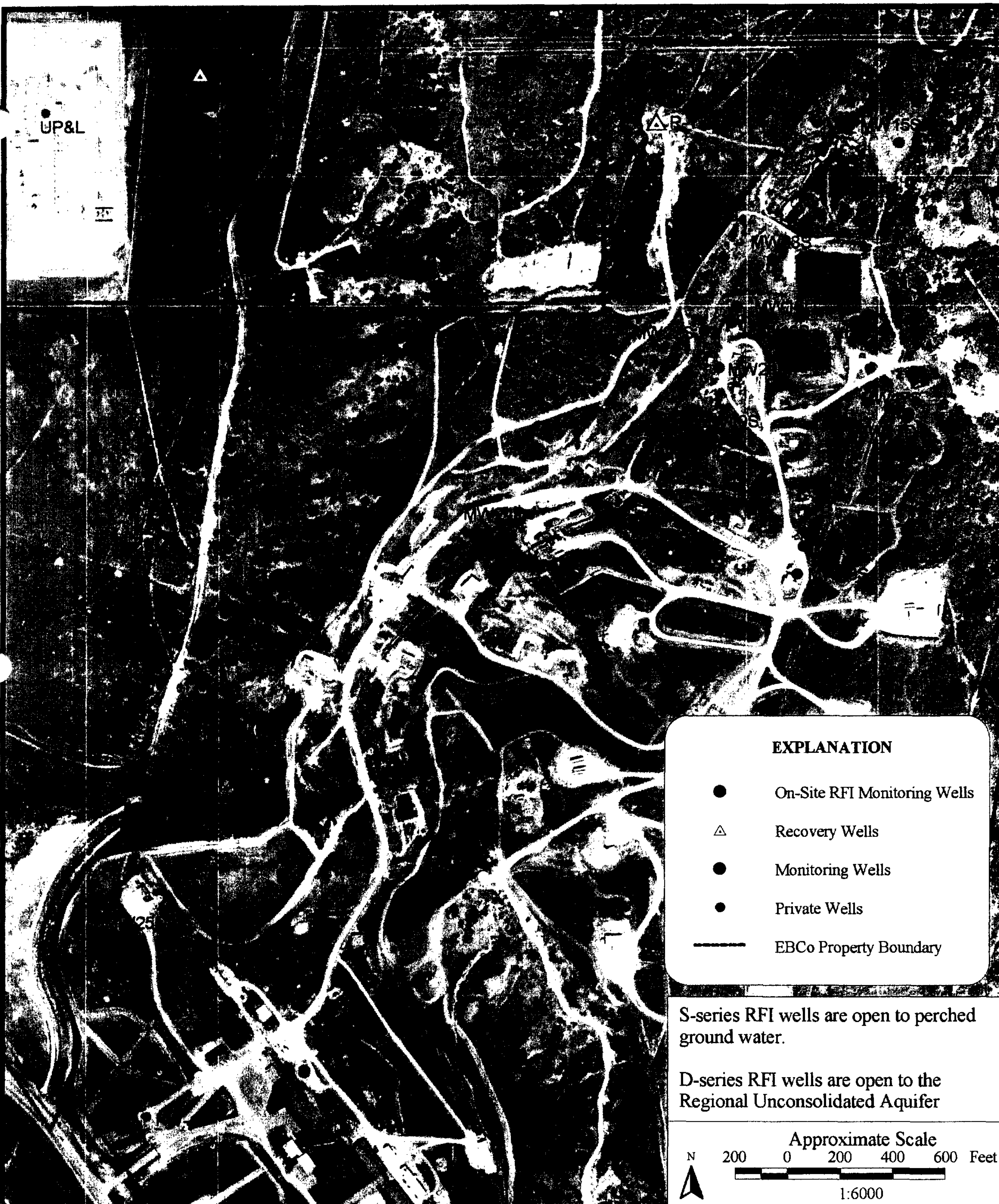
Water quality data from a deeper interval of perched ground water, identified during the RFI, indicate that this deeper interval was also recharged, at least in part, from process wastewater. The presence of certain constituents, notably NG and sulfate, coupled with the fine grained and low permeability nature of saturated subsurface materials, suggests that this perched ground water, at least in places, moves very slowly at the present time, if at all. The past behavior of this perched ground water when surface wastewater management was occurring is not known, but this perched ground water may have discharged to the regional aquifer system under past hydraulic conditions. The present relationship between perched ground water identified in this area and the underlying regional aquifer is the subject of ongoing investigation.

As noted in Section 6.5.1.4, relatively shallow perched ground water was historically present at a depth of about 30 to 50 feet below ground surface in the northeast corner of the EBCo site. In approximately 1980, PELA installed several monitoring wells (shallow B-series wells) that were open to this upper perched ground water interval. Engineering Science (1989 and 1990) performed additional investigatory work and determined that the clay layer underlying this uppermost level of perched ground water was tilted slightly to the northeast and that perched ground water flow was directed to the northeast. Water level data from the shallow B-series wells that were open to this perched ground water indicate that perched ground water levels fell below the base of these wells in the early 1990's and the shallow B-series wells remain dry to this day. This observation coincides with the discontinuance of wastewater discharges to the ground in this area in 1991. While some saturated materials were encountered within this and other depth intervals during the RFI soil boring program, these saturated zones were thin, fine grained, laterally discontinuous and did not produce sufficient water to install monitoring wells. Considering the forgoing, the historic shallow perched ground water and other minor saturated zones encountered during drilling are not of concern in the context of the CAP and will not be discussed further.

During the RFI drilling program, a deeper interval of perched ground water was identified in this same area. Figure 6-24 presents the locations of monitoring wells that have been installed at the EBCo site as part of the ongoing RFI. Wells that have an "S" designation (e.g. MW-15S) are open to perched ground water that is above the regional unconsolidated aquifer. Monitoring wells that have a "D" designation (e.g. MW-15D) are open to the regional unconsolidated aquifer. Saturated conditions have been found over a depth range of approximately 70 to 105 feet below the ground surface. With the exception of the MW-17S/MW-17D well pair, the base of this deeper perched ground water is approximately 75 to 105 feet above the top of the zone of saturation of the regional unconsolidated aquifer. At the MW-17S/17D well pair the perched ground water is approximately 37 feet above the top of the zone of saturation of the regional unconsolidated aquifer. Based on observations made during the RFI monitoring well drilling program, other noteworthy zones of perched ground water were not identified between the base of the perched ground water and the top of the zone of saturation of the regional unconsolidated aquifer.

The area of perched ground water appears to be constrained within the small structural graben in this area bounded by an antithetic fault to the west, Crowd Canyon alluvial fan deposits to the north and the main trace of the Wasatch Fault to the east. To the south, perched ground water was not observed in soil borings SB-4 and SB-5 (see Figure 6-11) nor was it present at the location of MW-24D. Spatial variability within the zone of perched ground water is evidenced by the lack of significant water encountered in abandoned monitoring well MW-20S, located approximately 200 feet east of MW-21S. Lithologic information from B-9, MW-16S and MW-23S suggests that a clay unit located west of the antithetic fault may prevent the westward movement of perched ground water in this area. This is consistent with the current conceptual hydrogeologic model of this area and is also consistent with Engineering Science's evaluation of shallow perched ground water that was historically present at a depth of approximately 30 to 50 feet in 1989 (Engineering Science, 1989 and 1990).

Lithologic information from soil borings in this area is indicative of a heterogeneous assemblage of interbedded sand, gravel, silt and clay. Coarser grained materials are generally found along the eastern margin of this area (MW-15S, MW-15D, MW-17S and MW-17D), adjacent to the mountains, with finer grained materials more prevalent to the west (MW-16S, MW-16D, MW-19S, MW-21S, and MW-22S). It is difficult to trace continuous lithologies across this relatively small area, indicative of the high degree of vertical and lateral heterogenaity. This is not unexpected given the complex depositional environment that was present at the basin edge and the complex faulting in this area. The cross-sections presented in Figure 6-13 are of too large a scale to accurately depict the detailed lithology in this area and do not include information from soil borings completed during the RFI. Detailed cross-sections through this area will be presented in the RFI Summary Report.



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Locations of Recently Installed On-Site RFI Monitoring Wells

FIGURE 6-24

Available data suggest that this area of perched ground water is of limited lateral extent and thickness. Based on lithologic information from boring logs and water level data collected from the monitoring wells open to the perched ground water, the thickness of the perched ground water in November 2001 ranged from approximately 9 feet, in the area of MW-21S to 29 feet at the location of MW-15S. The average thickness of this zone of perched ground water is approximately 16 feet. Assuming an average effective porosity of 0.20 and an area encompassing the zone of perched ground water of 1,720,000 square feet, this represents approximately 5,504,000 ft^3 (41,169,920 gallons) of perched ground water. For perspective, the regional unconsolidated aquifer in the area directly below the perched ground water is calculated to contain approximately 1.72×10^8 ft^3 (1.29×10^9 gallons) of water, assuming an area of 1,720,000 ft^2, an average effective porosity of 0.20 and a saturated thickness of 500 feet. Following this logic, the estimated volume of perched ground water in the northeast corner of the EBCo site is approximately three percent of the volume of ground water contained in the regional unconsolidated aquifer directly below the perched ground water. For perspective, using the same values for aquifer thickness and effective porosity, the volume of ground water contained in the regional unconsolidated aquifer within the study area (approximately 13 square miles) is calculated to be 3.6×10^{10} ft^3 (2.7×10^{11} gallons). The volume of perched ground water in the northeast corner of the EBCo site is about 0.02 percent of the volume of ground water in the regional unconsolidated aquifer within the study area.

Alternatively, the perched ground water can be compared to the regional aquifer system in terms of discharge (Q). Discharge is a measure of the volumetric flow rate of ground water moving through a cross-sectional area of saturated deposits. Discharge is the product of hydraulic conductivity, hydraulic gradient and cross-sectional area and is calculated using the following form of Darcy's equation:

$$Q = KiA$$

Where

Q = Discharge (L^3/T)
K = Hydraulic Conductivity (L/T)
i = Hydraulic Gradient (unitless)
A = Area through which the flow occurs (L^2)

Alternatively, Q can also be calculated using transmissivity data. Darcy's equation is modified as follows:

$$Q = TiW$$

Where

Q = Discharge (L^3/T)
T = Transmissivity (L^2/T)
i = Hydraulic Gradient (unitless)
W = Width of the vertical section through which the flow occurs (L)

Lithologic data indicates that the perched ground water containing the highest concentrations of solutes is primarily found in silts and silty sands. According to Fetter (1980), the hydraulic conductivity for these materials ranges from about 0.003 to 3 ft/d, with 3 ft/d probably representing a conservatively high estimate of hydraulic conductivity for the subsurface materials in the area of interest (vicinity of MW-16S, MW-19S, MW-21S and MW-22S). A preliminary evaluation of water level data indicates an average hydraulic gradient for the perched ground water system of about 0.03. The average thickness of the perched ground water zone is approximately 16 feet. Assuming a lateral distance of 1,000 feet, the calculated discharge of the perched ground water system ranges from approximately 1.4 to 1,400 ft^3/d (11 – 11,000 gpd) over the cited range of hydraulic conductivity. A similar calculation for the regional unconsolidated aquifer using transmissivity of 3,000 ft^2/d (from R-1 pump test), a hydraulic gradient of 0.05 and a width of 1,000 feet yields a discharge of 150,000 ft^3/d (1,122,000 gpd). Conservatively assuming that all of the perched ground water discharges to the regional aquifer, these calculations indicate that the discharge of the perched ground water represents between 0.001% and 1% of the discharge through the regional aquifer at this location in the northeast corner of the Plant. The selection of the lateral distance of 1,000 feet to calculate the cross-sectional area through which the perched ground water and regional ground water discharges is somewhat arbitrary and this distance was selected only to facilitate this comparison. Under the conservative assumption that all of the perched ground water discharges to the regional unconsolidated aquifer over some length, it is reasonable to assume that the perched ground water mixes with the regional unconsolidated aquifer over that same distance. Therefore, regardless of the lateral distance selected (i.e. 100 feet or 1,000 feet), the same relationship between discharge in the perched ground water and regional aquifer will be observed. Additional data collection may enable future refinement of this estimate during ensuing analyses.

Table 6-4 presents selected preliminary water quality data from the RFI monitoring wells. Only those data considered to be relevant to the CAP are presented in Table 6-4. Tables containing all the preliminary data available from the RFI monitoring wells were provided to DWQ with a cover letter dated July 17, 2001 along with the draft soil boring logs for completed monitoring wells. It is that preliminary water quality data set on which this discussion is based. Additional draft soil boring logs prepared during the RFI were provided to DWQ with a cover letter dated July 19, 2001. In addition to nitrate-nitrogen and CEMs, sulfate and lead have been included in Table 6-4. Sulfate is included because its presence may be related to the use of sulfuric acid in the formulation of NG/EGDN. Lead is included because the NG/EGDN nitrator/specialty nitrates building (SWMU 31) had a lead floor and lead was observed to be present in some soil samples collected from SWMU 31. Other parameters, such as chloride, sodium, calcium and magnesium are not presented in Table 6-4 because these compounds are not known to be related to Plant production activities. However, general water chemistry data from these monitoring wells have been used to prepare Piper and Stiff diagrams to illustrate and compare the general water chemistry characteristics of the perched ground water and ground water within the regional unconsolidated aquifer in the immediate area.

Table 6-4: Selected Preliminary Analytical Data from RFI Monitoring Wells

Analyte (units)	RFI Monitoring Well													
	MW-15S	MW-15D	MW-16S	MW-16D	MW-17S	MW-17D	MW-18S	MW-18D	MW-19S	MW-21S	MW-22S	MW-23S	MW-24D	MW-25D
Anions (mg/L)														
Nitrate-nitrogen	3.17	7.49	892	46.8	1.3 J	0.05	0.3 B	2.7	21	13	33	1480	0.83	0.6[a]
Sulfate	27	62	1000	61	28 B	13.1	110	31	620	590 B	410	1200	25	147 B
Metals (mg/L)														
Lead (total)	NA	0.0027	0.0487	0.004	0.0027 UB	0.0827	NA	0.0051	0.0027	0.0037	0.0082	<0.005	0.0034 UB	0.005
Lead (dissolved)	NA	NA	<0.005	<0.005	0.0018 UB	0.0017 UB	NA	<0.005	0.00077	0.0017	0.0025 T	<0.005	<0.005	0.004 T
CEMs (µg/L)														
HMX	**0.87**	**1.51**	**73.6**	<0.5	<0.5	<0.5	<0.5	<0.5	**0.91**	**18.3**	<0.5	**0.31 T**	<0.5	<0.5
RDX	**2.92**	**12.4**	**728**	<0.42	**0.26 T**	<0.42	<0.42	<0.42	**46.5**	**340**	**10.8**	**121**	<0.42	<0.42
TNT	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
2,4-DNT	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24
2,6-DNT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	**0.23 J**	<0.3	**1.45**	<0.3	<0.3	<0.3
NG	<0.2	<0.2	**368**	<0.2	<0.2	<0.2	<0.2	<0.2	**8.29**	**5.12**	**7.79**	<0.2	<0.2	<0.2
EGDN	<0.68	<0.68	**403**	<0.68	<0.68	<0.68	<0.68	<0.68	**5230**	<0.68	**3960**	<0.68	<0.68	<0.68
DEGDN	<0.94	**0.96**	**318**	<0.94	<0.94	<0.94	<0.94	<0.94	**4670**	**14.6**	**20500**	<0.94	<0.94	<0.94
TEGDN	<0.34	<0.34	**312**	<0.34	<0.34	<0.34	<0.34	<0.34	**821**	**22.1**	**3760**	<0.34	<0.34	<0.34
TMETN	<0.46	**0.99**	**53.6**	<0.46	<0.46	<0.46	<0.46	<0.46	**21.9**	**50.9**	**122**	<0.46	<0.46	<0.46
BTTN	<0.46	<0.46	**15.6**	<0.46	<0.46	<0.46	<0.46	<0.46	**2.08**	<0.46	**12.7**	<0.46	<0.46	<0.46
PETN	**1.06**	**0.42 T**	**61.7**	<0.64	<0.64	<0.64	**3.90**	<0.64	**3.87**	**8.03**	<0.64	<0.64	<0.64	<0.64

Data obtained from Montgomery Watson Harza

[a] Not detected in duplicate sample

In those instances where a duplicate sample was analyzed, the average concentration is provided.

"S" series wells are open to perched ground water. "D" series wells are open to the regional unconsolidated aquifer.

Samples MW-15S, MW-16S and MW-18S were collected with a bailer. The remaining samples were collected using low flow sampling methods.

MDL	Method Detection Limit
PQL	Practical Quantitation Limit
NA	Not analyzed
UB	Analyte is considered not detected
B	Analyte detected in associated blank
J	Data are estimated
T	Analyte concentration less than the PQL but greater than MDL and should be considered estimated

Figure 6-25 is a Piper diagram for the monitoring wells installed during the RFI and selected monitoring wells that are open to the regional unconsolidated aquifer in this vicinity. The Piper diagram indicates that ground water within the regional unconsolidated aquifer in this area generally is of the calcium bicarbonate type. This is consistent with the water chemistry observed in the evaluation of regional aquifer and bedrock aquifer wells throughout the study area presented in Section 6.6.3. Perched ground water having a calcium bicarbonate signature is also observed in areas closest to the mountain front and having no or low concentrations of CEMs and nitrate (MW-15S, MW-17S and MW-18S). This may reflect a lack of impact from past wastewater discharges and/or flushing due to the introduction of clean ground water recharge. However, the perched ground water in the area of the five wells having the highest concentrations of CEMs and nitrate (MW-16S, MW-19S, MW-21S, MW-22S and MW-23S) exhibits a markedly different water chemistry signature in the calcium sulfate to calcium chloride range. This water chemistry signature probably reflects the influence of historical wastewater discharges.

The Stiff diagrams presented in Figure 6-26 also illustrate the similar water chemistry and lower ionic strength of ground water from wells open to the regional unconsolidated aquifer and those perched ground water wells located closest to the mountain front. The five wells open to the perched ground water having the highest concentrations of CEMs and nitrates have different chemical signatures, indicating relatively high ionic strength and relatively higher amounts of sulfate and chloride. The relatively high levels of calcium and magnesium in these wells may reflect the collection of turbid samples due to the fine grained nature of materials in which the well screens were set.

A comparison of water quality data from perched ground water and regional aquifer wells illustrates a dichotomy in constituent concentrations. Relatively high concentrations of nitrate-nitrogen, sulfate and various CEMs are observed in perched ground water in the northeast corner of the Plant in the vicinity of SWMU 30, whereas substantially lower concentrations or non-detections are observed for the deeper regional aquifer wells in the area. This is particularly notable at the MW-16S/MW-16D well pair where relatively high concentrations of CEMs were detected at MW-16S and no CEMs were detected in MW-16D. These data, along with observations regarding the lack of continuously saturated conditions in the interval between the base of the perched ground water and the top of the zone of saturation of the regional unconsolidated aquifer, provide conclusive evidence that perched ground water has not migrated vertically downward to the underlying regional unconsolidated aquifer in vicinity of MW-16D. The presence of approximately 47 mg/L nitrate-nitrogen and the absence of CEMs at MW-16D may be indicative of releases from the dilute nitric acid storage ponds that were located to the east.

Of interest is the presence of NG and sulfate in the perched ground water. NG has not been detected in off-site monitoring wells that are open to the regional aquifer, nor has NG been identified in the regional aquifer wells installed during the RFI. The presence of relatively high concentrations of sulfate may reflect the historical use of sulfuric acid in the NG/EGDN manufacturing process. NG/EGDN processing at the site began in

Figure 6-25: Piper Diagram of General Water Chemistry Data from Perched Ground Water and Selected Regional Aquifer Wells in the Northeast Area of the EBCo Property

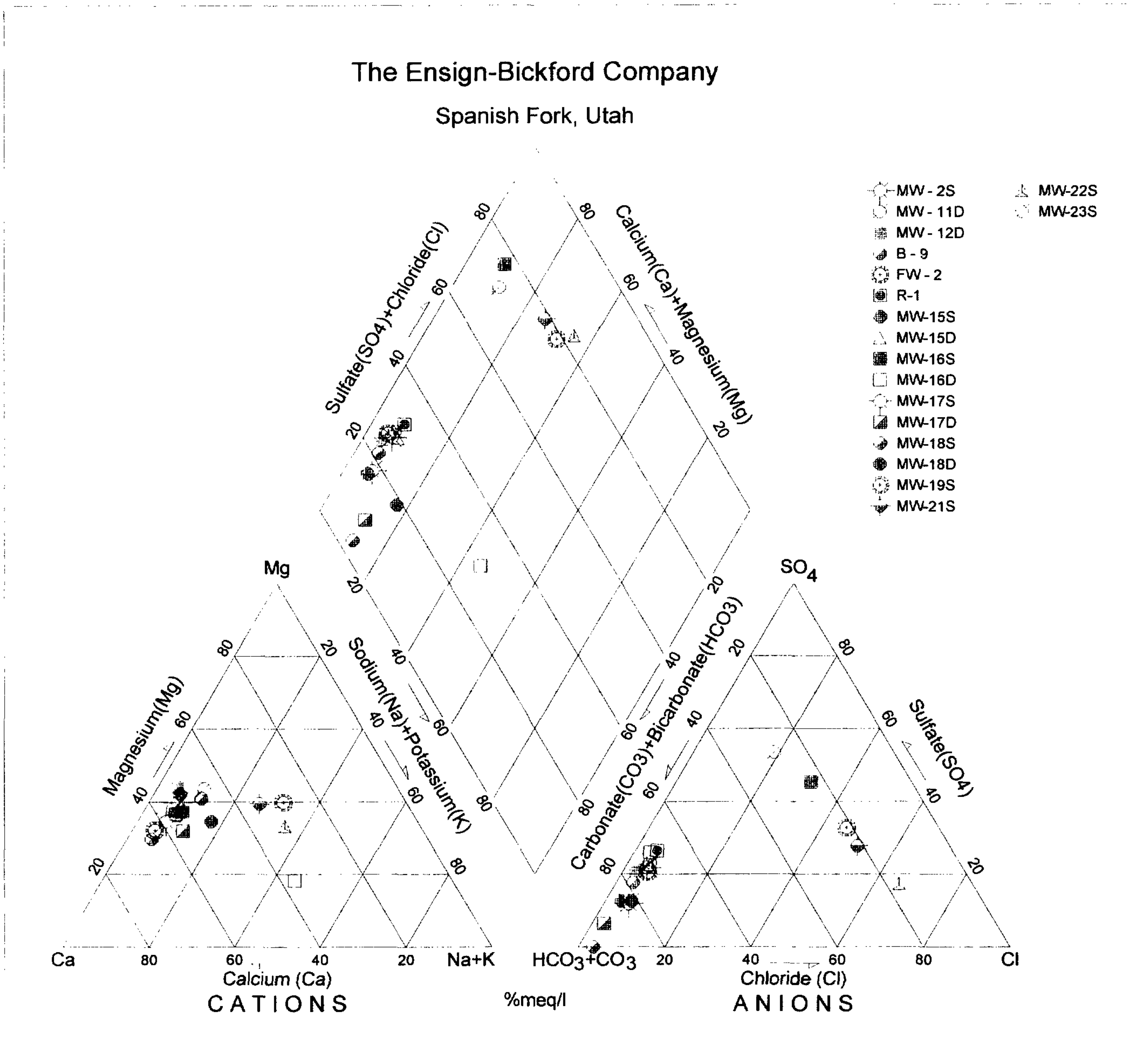
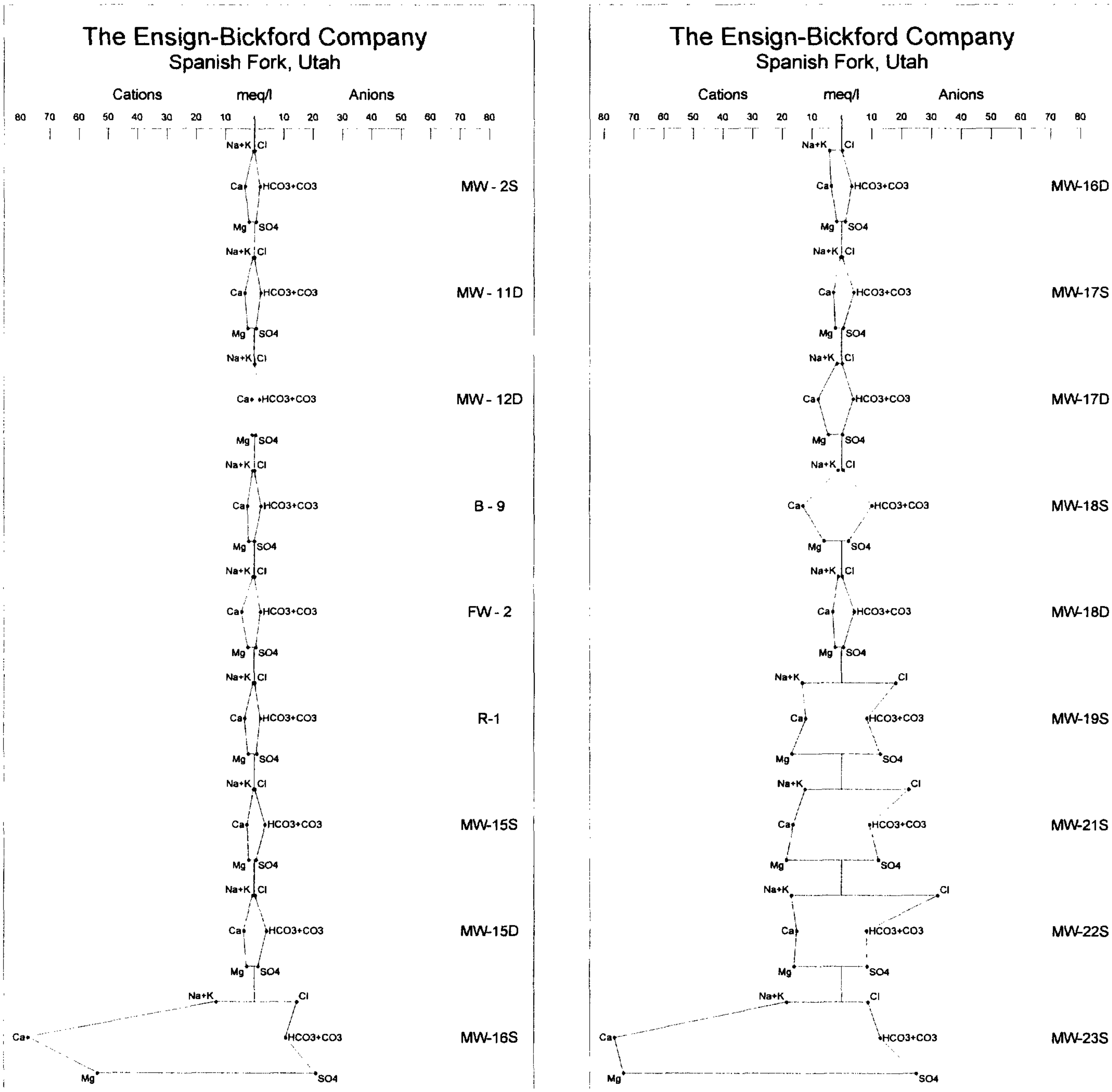


Figure 6-26: Stiff Diagrams of General Water Chemistry Data from Perched Ground Water and Selected Regional Aquifer Wells in the Northeast Area of the EBCo Property



1941 and concluded in 1963. These data suggest that the perched ground water present in this area is relatively old and migrates very slowly, if at all.

Perched ground water data also show substantial spatial variability. CEM constituents and concentrations vary considerably from location to location. Generally, higher concentrations of CEMs in perched ground water are found close to historic manufacturing locations or along former wastewater conveyance structures. The presence of relatively high concentrations of specialty nitrate compounds in MW-19S, MW-21S and MW-22S is notable and may be indicative that a portion of the wastewater discharges from the specialty nitrates manufacturing process infiltrated into the subsurface along the conveyance channel. Specialty nitrate concentrations have probably remained relatively high at these locations due to the low permeability of the subsurface materials and very slow movement of the perched ground water. Concentrations of specialty nitrate compounds present in some perched ground water wells are about one to three orders of magnitude higher than specialty nitrate concentrations observed in the regional unconsolidated aquifer.

Dissolved lead concentrations in both the regional unconsolidated aquifer and the perched ground water are below the 0.015 mg/L ground water quality standard established in the Utah Administrative Rules for Ground Water Quality Protection (1995, Table 1). Total lead concentrations at two locations (MW-16S and MW-17D) exceed 0.015 mg/L. It is our understanding that the MW-16S sample was collected with a bailer shortly after the well was completed and the collected sample was quite turbid. The elevated total lead concentration in this sample likely reflects the turbid nature of the sample. The non detectable dissolved lead concentration from the MW-16S sample is supportive of this hypothesis. The cause of the elevated total lead concentration at MW-17D remains undetermined. MW-17D is not located in an area that should be affected by production activities. The sample from MW-17D was collected using low flow sampling methods; however, it is our understanding that this sample was collected shortly after the well was developed. Dissolved lead was not detected in this sample possibly indicating that the total lead detection could be related to particulates present in the unfiltered sample. Additional data collection will be necessary to resolve these issues.

Based on the preliminary assessment of water quality data and lithologic data that are currently available, three additional monitoring wells, two open to the perched ground water and one open to the regional unconsolidated aquifer, will be constructed within the small graben located in the northeast corner of the EBCo site. The purpose of these wells is to collect additional lithologic and water quality data to better refine the conceptual hydrogeologic model of this area and to better understand the distribution of solutes within the perched ground water and regional aquifer at this location. A soil boring will also be installed on the plateau to the west of graben; south of B-9 and west of MW-16S, MW-19S, MW-21S and MW-22S. The purpose of this soil boring is to assess the lithology in this area and to determine if perched ground water is present a depths consistent with the perched ground water identified to the east in the area of SWMUs 1 and 30. If sufficient perched ground water is identified in the appropriate depth range, a monitoring well will be constructed at this location. Data from these three new wells and soil boring are not available for incorporation into this document. This new information will be incorporated into the pending RFI Summary Report.

Nitrate-nitrogen concentrations in the regional aquifer at MW-24D and MW-25D were below 1 mg/L. CEMs were not detected at these locations.

Perched ground water, in sufficient quantity to enable monitoring well construction and sampling, was only encountered in the northeast corner of the Plant. Even in this area, the lack of sufficient saturated subsurface conditions precluded the installation of one proposed monitoring well (MW-20S). Sufficient perched ground water was not encountered in the northwest corner of the Plant (SWMU 26) nor was perched ground water observed in the area of MW-24D (SWMU 19).

The available data suggest that the perched ground water identified in the northeast corner of the EBCo site is not having an adverse, ongoing impact on water quality in the regional unconsolidated aquifer. The following observations support this preliminary conclusion:

- Water quality data from the regional aquifer in the vicinity of the perched ground water provide indirect evidence that the perched ground water does not have significant ongoing impact on the regional aquifer. Nitrate and CEM concentration trends in this area are declining or becoming asymptotic, which is consistent with the trends expected at the trailing edge of a release event (such as the termination of wastewater discharges to the ground in 1991). While there may be some contribution of solutes to the regional unconsolidated aquifer from the perched ground water, it does not appear to have an adverse effect on water quality.

- The volume of perched ground water present in the northeast corner of the EBCo site is very small compared to the volume of water contained within the regional unconsolidated aquifer below the area of perched ground water.

- A preliminary analysis of ground water discharge through the perched ground water interval and underlying regional unconsolidated aquifer, using conservative assumptions, suggests that the volume of ground water moving through the perched ground water interval may range from about 0.001 to 1 percent of the volume moving through the regional unconsolidated aquifer in the northeast corner of the EBCo site. The upper end of the range (1%) is probably a conservatively high estimate due the presence of abundant low permeability silts and silty sands within the perched ground water interval.

- General water chemistry data from the regional unconsolidated aquifer, bedrock aquifer and perched ground water located away from historic wastewater management areas and/or proximal to recharge sources, shows the natural ground water in the study area to be of the calcium bicarbonate type. The water chemistry signature of perched ground water in areas having the highest concentrations of solutes (MW-16S, MW-19S, MW-21S, MW-22S and MW-23S) is markedly different, being of the calcium sulfate to calcium chloride type. This water chemistry signature is probably indicative of historic wastewater discharges. Three observations are made from these data: 1) perched ground water in the most affected area has not received sufficient recharge to return the water quality signature to the natural background calcium bicarbonate type; 2) this area of perched ground water is moving very slowly or may be static; and, 3) the quantity of perched ground water that might be discharging to the regional unconsolidated aquifer is not sufficient to noticeably alter the chemical signature of ground water in the regional unconsolidated aquifer.

- The highest concentrations of solutes in the perched ground water system are found in relatively fine grained, low permeability deposits. Ground water movement through these materials is very slow, relative to flow in the regional unconsolidated aquifer.

- Production of NG/EGDN at the Plant began in 1941 and ceased in 1963. The presence of NG and elevated concentrations of sulfate indicate that the perched ground water having the highest concentrations of constituents is possibly older and very slow to migrate. NG has not been detected in monitoring wells open to the regional unconsolidated aquifer

6.7.3.2 RFI Soils Data

Based upon a review of the available RFI analytical data, knowledge of process history and site-specific hydrogeologic information, soils in several SWMUs may currently act as continuing sources of constituents to ground water identified on the Plant site. Preliminary data indicates that perched ground water in the northeast corner of the Plant contains nitrate-nitrogen and CEMs. The degree to which these soils and perched ground water may act as a continuing source of impact to the regional aquifer system is the subject of ongoing investigation under the RFI. The general locations of SWMU 1, 26, 30, 31 and 42 are shown in Figure 6-27 and descriptions of these SWMUs are provided in Table 6-5.

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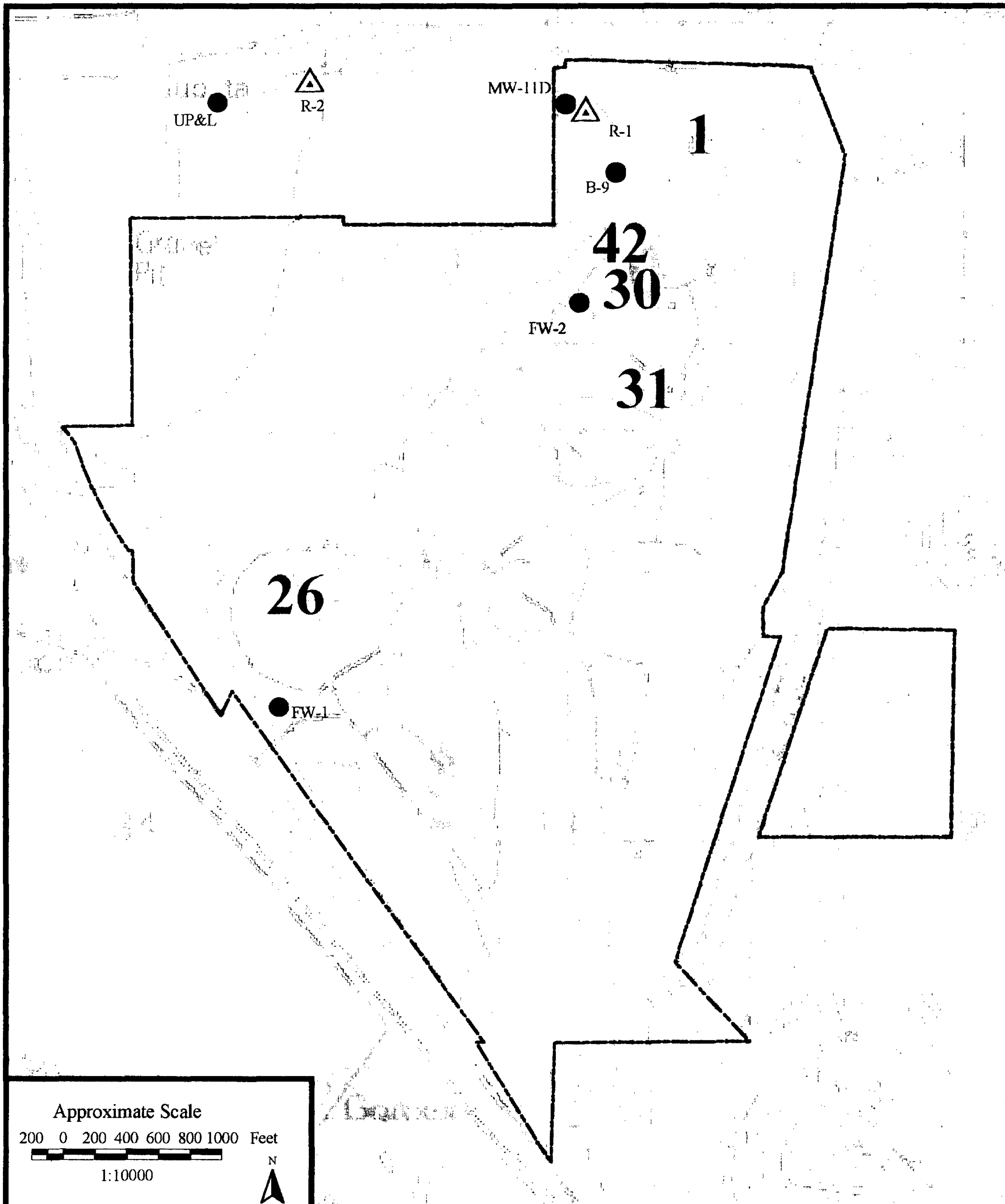

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SWMUs That May Be Potential Sources of Impact to Ground Water

FIGURE 6-27

Table 6-5: Potential Continuing On-site Sources to Ground Water

SWMU	Name	Description
SWMU 1	Conveyance Channel, North Impoundment and Wastewater Dispersion Area	This unit received wastewater, wash water and waste acid discharges from nitroglycerin production, PETN formulation, PETN crystallization, specialty nitrates formulation, RDX dewaxing, RDX waxing, RDX crystallization/re-crystallization and acetone recovery. PETN and RDX are the principal constituents identified in soils. Preliminary water quality data from monitoring wells installed in this area during the RFI are summarized in Table 6-4.
SWMU 26	Northwest Manufacturing Complex	This unit received discharges from acid recovery operations associated with nitroglycerin production and nitrostarch operations. A thin layer of nitrostarch has been identified in surface soils at this SWMU. A ground water grab sample from perched ground water present approximately 40-feet below the land surface indicated the potential presence of nitrate and sulfate. However, no perched ground water was encountered in a temporary well point installed in this area during RFI monitoring well construction activities and no future attempts to intercept perched ground water that may be located within a portion of this area are planned. Preliminary water quality data from MW-25D, installed in this area, are summarized in Table 6-4. The presence of nistrostarch in soils in this SWMU is considered a possible continuing source of nitrate to ground water.
SWMU 30	Old PETN Nitrator Complex	Several former manufacturing buildings were located in this unit and a variety of production processes were performed in this unit. Process buildings include the old PETN nitrator, PETN recrystalizer, HMX/RDX recrystalizer (old spent acid house), RDX Pack House (old glycerin storage building), two acetone recovery stills and the Old Primer No. 1 building. Discharges from these buildings were directed to SWMU 1. PETN, TNT and RDX are the principal constituents identified in soils. This SWMU is located above perched ground water present in this area of the Plant site. Preliminary water quality data from monitoring wells installed in this area during the RFI are summarized in Table 6-4.
SWMU 31	Specialty Nitrates Building	This building and associated wastewater conveyance structures were used for the production of nitroglycerin and specialty nitrates. Lead has been detected in site soils. This unit is probably located above perched ground water in this portion of the Plant site.
SWMU 42	RDX Accumulation Tanks	These tanks were used to store waste mineral spirits and wax from RDX operations and later waste acetone and water from the acetone recovery operations. RDX and PETN are the principal constituents detected in site soils. This SWMU is located above perched ground water present in this area of the Plant site. Preliminary water quality data from monitoring wells installed in this area during the RFI are summarized in Table 6-4.

6.8 Constituents of Concern

The constituent of concern (COC) list is based primarily on detections of constituents in regional aquifer ground water over the history of the monitoring program. If a constituent has been consistently detected in the regional aquifer ground water monitoring program, it is included as a COC.

A "provisional" COC is one that may be attributable to historic manufacturing activities at the Plant and that has only been reported as detected very sporadically or sparsely to date. It may even be a constituent that has not been detected in the regional aquifer to date, but is still under investigation as part of the site characterization. As additional data is collected, provisional COCs may become COCs if they are determined to be present in the regional aquifer on a more consistent basis. On the other hand, a provisional COC will be eliminated from the COC and provisional COC lists if, after four consecutive quarters it is not detected at selected locations within the ground water monitoring network in the regional aquifer system. Details regarding proposed monitoring for the provisional COCs are presented in Section 12.6 of this CAP.

Table 6-6 lists the COCs and provisional COCs subject to consideration in the CAP.

Table 6-6: COCs and Provisional COCs

Constituents of Concern
RDX
HMX
PETN
EGDN
DEGDN
TEGDN
TMETN
BTTN
Nitrate-nitrogen
Provisional Constituents of Concern
2,4,6-TNT
2,4-DNT
2,6-DNT
NG
Lead

Sampling and analyses for chlorinated solvents (HVOCs), volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) was performed during earlier phases of the hydrogeologic investigation (DSHW split sampling, 1995). Results have indicated that these compounds have not been detected in the regional aquifer. These compounds are eliminated from further consideration and are not included as COCs or provisional COCs.

There is no state ground water quality standard for sulfate. The federal secondary maximum contaminant level (SMCL) for sulfate is 250 mg/L. Secondary drinking water standards are not enforceable and are established for aesthetic purposes. Sulfate data have been collected periodically throughout the hydrogeologic investigation and concentrations in the regional aquifer are well below the 250 mg/L SMCL. Sulfate concentrations exceed the SMCL in five monitoring wells that are open to perched ground water present in the northeast area of the Plant. As noted in Section 6-6, during certain times of the year, relatively high sulfate concentrations are reported for the Spanish Fork River. Because the regional aquifer is recharged, in part, by the Spanish Fork River, this is a source of sulfate to the regional aquifer. For these reasons sulfate is not considered to be a COC or provisional COC.

Nitroglycerin (NG) is listed as a provisional COC because, although it has not been detected within the regional aquifer ground water monitoring network over a five year monitoring period, it has been detected in four perched ground water samples collected from the Plant in the area of SWMU 1 and SWMU 30. Therefore, since the perched ground water is considered to be a potential source of constituents to the regional aquifer, NG is currently classified as a provisional COC. NG was not detected in initial samples from the RFI monitoring wells that are open to the regional aquifer. If NG is detected in selected monitoring wells that have recently been installed in the northeast portion of the Plant and that are open to the regional aquifer, NG will be confirmed as a COC. If NG is not found to be present in the regional aquifer at any location at detectable levels over a period of four quarters, it will be removed from the provisional COC list.

In the case of 2,4,6-TNT, 2,4-DNT and 2,6-DNT, these constituents are included as provisional COCs and they may be eliminated from the future monitoring program if it is confirmed that they are not present in the regional aquifer. To date there have been only a very few reported detections of the compounds 2,4,6-TNT and 2,6-DNT from wells open to the regional aquifer and up until 2001, 2,4-DNT was not reported by the laboratory. The compound 2,4,6-TNT has been detected a total of four times in two different wells with the highest concentration being 2.16 µg/L. The compound 2,6-DNT has been detected a total of four times in four different wells with the highest concentration being 0.47 µg/L. In the vast majority of monitoring events and samples, these compounds have not been detected in the regional aquifer. Current monitoring procedures are designed to confirm whether or not any or all of these related compounds are currently present in the regional aquifer at detectable levels. During 2001, the compounds 2,4,6-TNT, 2,4-DNT and 2,6-DNT were not detected in any well open to the regional aquifer. The compound 2,6-DNT was detected at very low concentrations in two perched ground water samples collected from the Plant in the area of SWMUs 1 and 30. After a period of four consecutive sampling events, each of the compounds will be evaluated to see if it should continue to be a provisional COC, be added as a COC or eliminated from the provisional COC list.

Total and dissolved lead data are available from several wells open to the regional aquifer. In 1992, dissolved lead was reported in MW-1S at a concentration of 0.027 mg/L (Dames and Moore, 1992). Dissolved lead was not detected (<0.005 mg/L) in

MW-2S and UP&L in 1992 (Dames and Moore, 1992). In 1998, total lead was also identified in R-1 (0.06 mg/L) and MW-11D (0.34 mg/L) during the R-1 pump test (Charter Oak, 1998c). A dissolved lead concentration of 0.07 mg/L was reported for MW-11D during this same time period (Charter Oak, 1998c). In response to these lead results EBCo conducted additional sampling for both total and dissolved lead at MW-1S, MW-1D, MW-2S, MW-6D, MW-7D, MW-12 and B-9. Total or dissolved lead were not detected in these samples (<0.005 mg/L) (Charter Oak, 1998c). In February 1999 additional total lead samples were collected from the R-1 well in preparation for making this well operational as part of the ground water extraction system. Total lead was not detected (<0.005) mg/L in samples collected prior to and after GAC treatment. Based on these data, lead is not identified as a constituent of concern. However, lead is listed as a provisional COC because of RFI soils data from SWMU 31 and because of preliminary total lead data available from on-site RFI monitoring wells.

Four quarters of monitoring is considered to be sufficient to confirm the absence of provisional COCs if the results are consistently below detection limits. This is due to two factors. First, concentrations near the facility have exhibited declining trends and are expected to continue this trend. Second, the active sources of these constituents were eliminated from the facility years ago. These factors create an expectation that any concentrations of these constituents would decrease rather than increase over time. Therefore, if there are no detections for four consecutive quarters, it is very unlikely that there would be any subsequent detections.

One additional source of information that was considered in determining the COC list is on-site soil. Discharges to the ground containing the COCs ceased many years ago, but soils containing some of these constituents remain on the site. The cessation of discharges has eliminated what are considered to be the most important potential sources of impacts to the regional aquifer. A formal evaluation of threats to ground water from on-site soils is being conducted as part of the RFI.

With regard to the provisional COCs, the RFI soil sampling data indicate that these constituents are not present at concentrations or depths that would suggest that they might represent continuing sources of contamination that would result in concentrations above proposed CACLs in the regional aquifer. Detections of these constituents are most heavily weighted to soils no more than five feet below grade. The few detections reported below five feet below grade are at relatively low concentrations. In addition, SWMU 1 is arguably the unit most heavily affected by these constituents and the perched ground water collected below this unit was not found to contain detectable concentrations of these constituents. Therefore, the RFI soil data supports the designation of NG, 2,4-DNT, 2,6-DNT, 2,4,6-TNT and lead as provisional COCs.

6.8.1 Media of Occurrence

The COCs are present in the dissolved phase in ground water. As a consequence, CEMs probably are adsorbed to materials that comprise the regional aquifer. Based on sampling and analysis performed during the RFI, CEMs are present in on-site soils at many of the

SWMUs. Depending on the SWMU, individual CEM concentrations in soils range from less than 1 mg/kg to more than 30,000 mg/kg in some samples. The highest concentrations of CEMs are typically found in surface soils with higher concentrations generally found in the upper five feet of the soil column. CEM concentrations in soils tend to decline with increasing depth.